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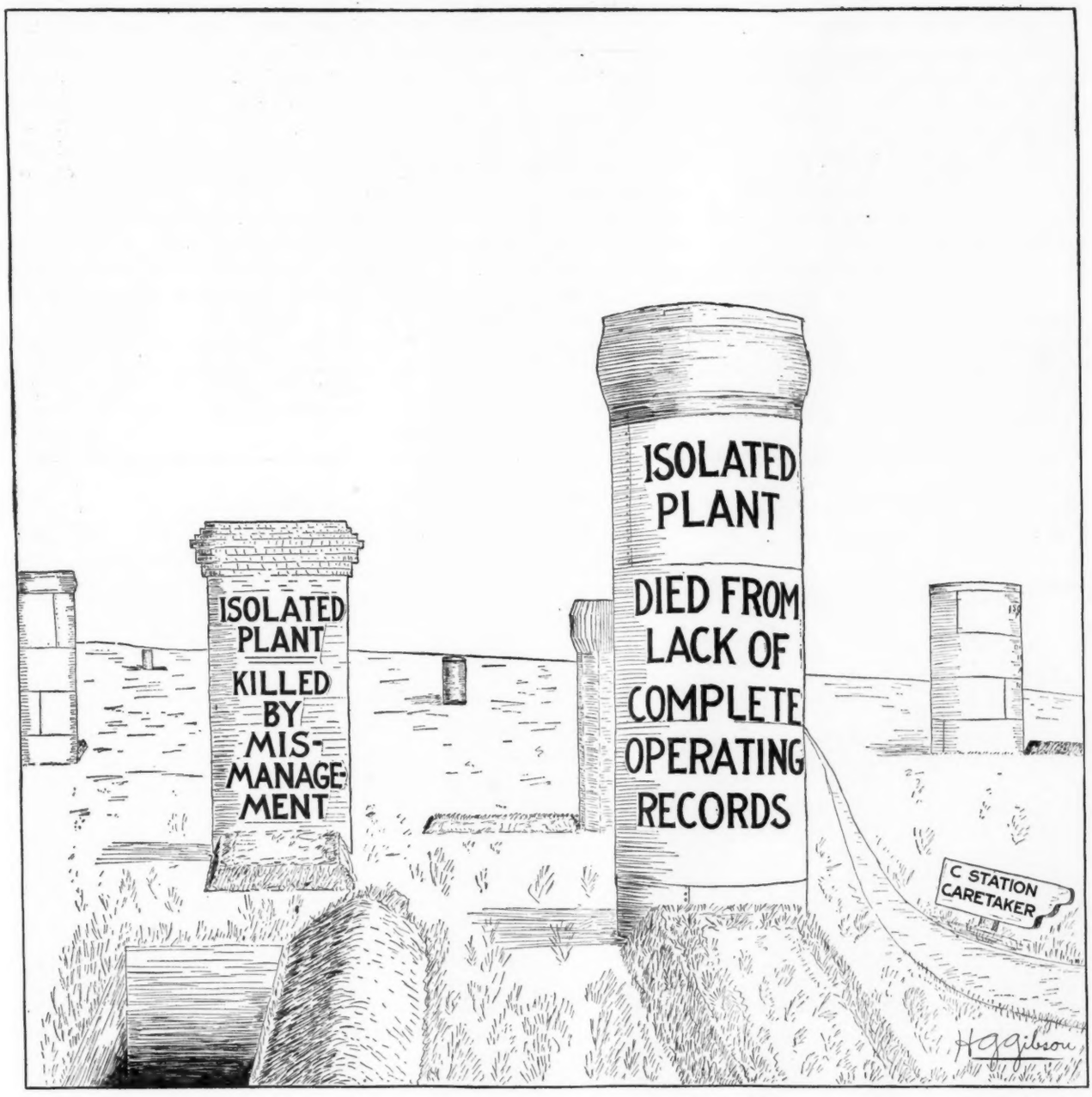


As One Reader Sees It

Collinsville Plant Remodeled

BY THOMAS WILSON

Reconstructing a 1000-kw. plant while maintaining equipment in constant operation. The boilers were operated in the open for three months. The station will eventually have a capacity of 8000 kilowatts.

IN 1910 the Southern Illinois Light and Power Co. built a 1000-kw. plant at Collinsville, Ill., a town then having a population of 5000 and situated 20 miles east of St. Louis. The plant was to furnish light and power to Collinsville and the surrounding district, which contained a number of coal mines and afforded prospects for a considerable power load. The original generating installation consisted of two 500-kw. G. E. turbo-generators designed to furnish three-phase 60-cycle current at 2300 volts, the speed being 3600 r.p.m. The town was supplied at the generator voltage, but for transmission to O'Fallon, 12 miles distant, the voltage was stepped up to 33,000. On a vacuum of 27 in. maintained by jet condensers driven by noncondensing turbines, the water rate for these units at full load was 23 lb. per kw.-hr. A forced-draft cooling tower conserved the condenser water for one unit, and a natural-draft tower designed by the company's engineer served the other unit. With no condensate for the boiler feed, it was necessary to soften the city water used in the plant, as it came from deep wells and was too hard for boiler use. For this purpose a 1000-hp. Reisert purifier having a capacity to soften 4000 gal. of water per hour was installed.

Steam was supplied at 140 lb. gage pressure by two Lyons boilers served by inclined-grate stokers. The fuel was Illinois screenings, 1½ in., obtained from a near-by mine. Owing to increasing demands for current it was impossible to handle the load satisfactorily with these two boilers, so they were eventually supplemented by two 400-hp. Stirling boilers served by chain grates. Each boiler had an individual steel stack.

In February, 1916, the Arnold Co., of Chicago, was requested to report upon the advisability of plant extension and means of providing for it, a careful survey of the surrounding territory covering several counties, to estimate the possible growth in business, having been made by the electric company. It was desired to run a transmission line to Hillsboro and tie in the Collinsville plant with the company's station at this point. Determination of the size and type of units best adapted to the load was the next step. The proposed layout of the remodeled station is shown in Fig. 1. Eventually it will contain two 3000-kw. generating units, one of 1500-kw. capacity and a 500-kw. machine, the last-named being one of the generating units now in service. The new 1500-kw. unit is now installed. It is a three-phase 60-cycle machine generating at the same voltage and speed as the machines comprising the original installation.

A careful analysis of the relative costs and of the local conditions regarding feed-water supply resulted in the choice of a surface condenser for the new unit. The extra cost of treating the feed water that would have been necessitated by a jet condenser and the slight increase in power for pumping more than overbalanced the fixed charges on the difference in investment, the first cost of the surface condenser being greater. The condenser installed contains 2880 sq.ft. of cooling surface, or 1.92 sq.ft. per kilowatt of generator rating. It is served by a motor-driven single-stage hotwell pump having a capacity of 110 gal. per min. against a total of 60-ft. head, and a single-runner double-suction circulating pump that can deliver 3000 gal. per min. against a head of 45 ft. The circulating pump is driven by a single-stage noncondensing turbine through reduction gearing, the reduction being from 3600 to 1150 r.p.m. The dry-vacuum pump is of the crank-and-flywheel type, valveless air suction, 6 and 10 x 14 in.

With the installation of the new unit it was necessary to increase the boiler capacity by 800 hp. Two 400-hp.

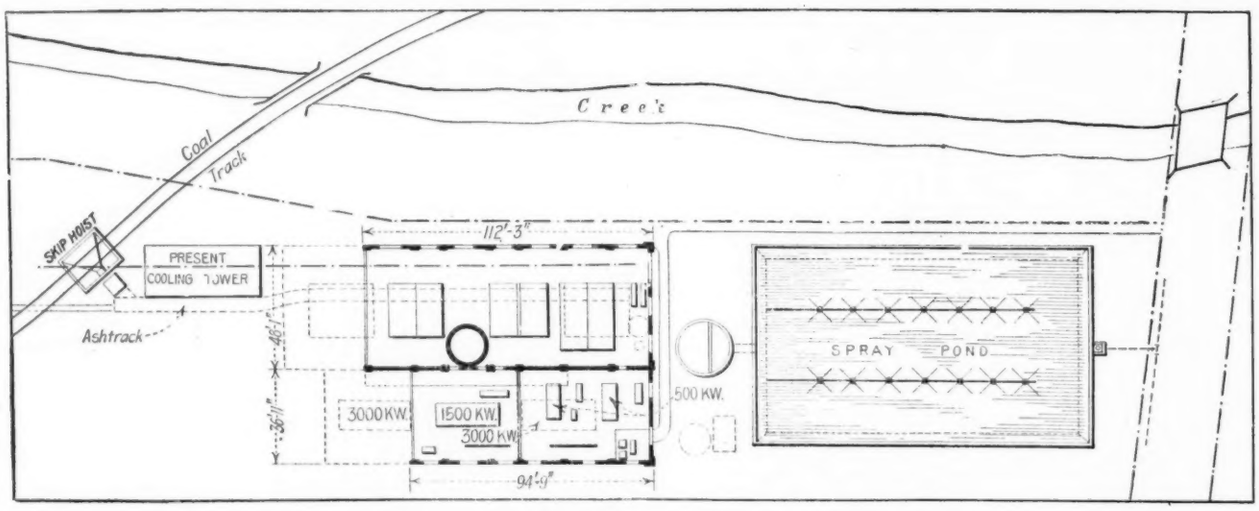
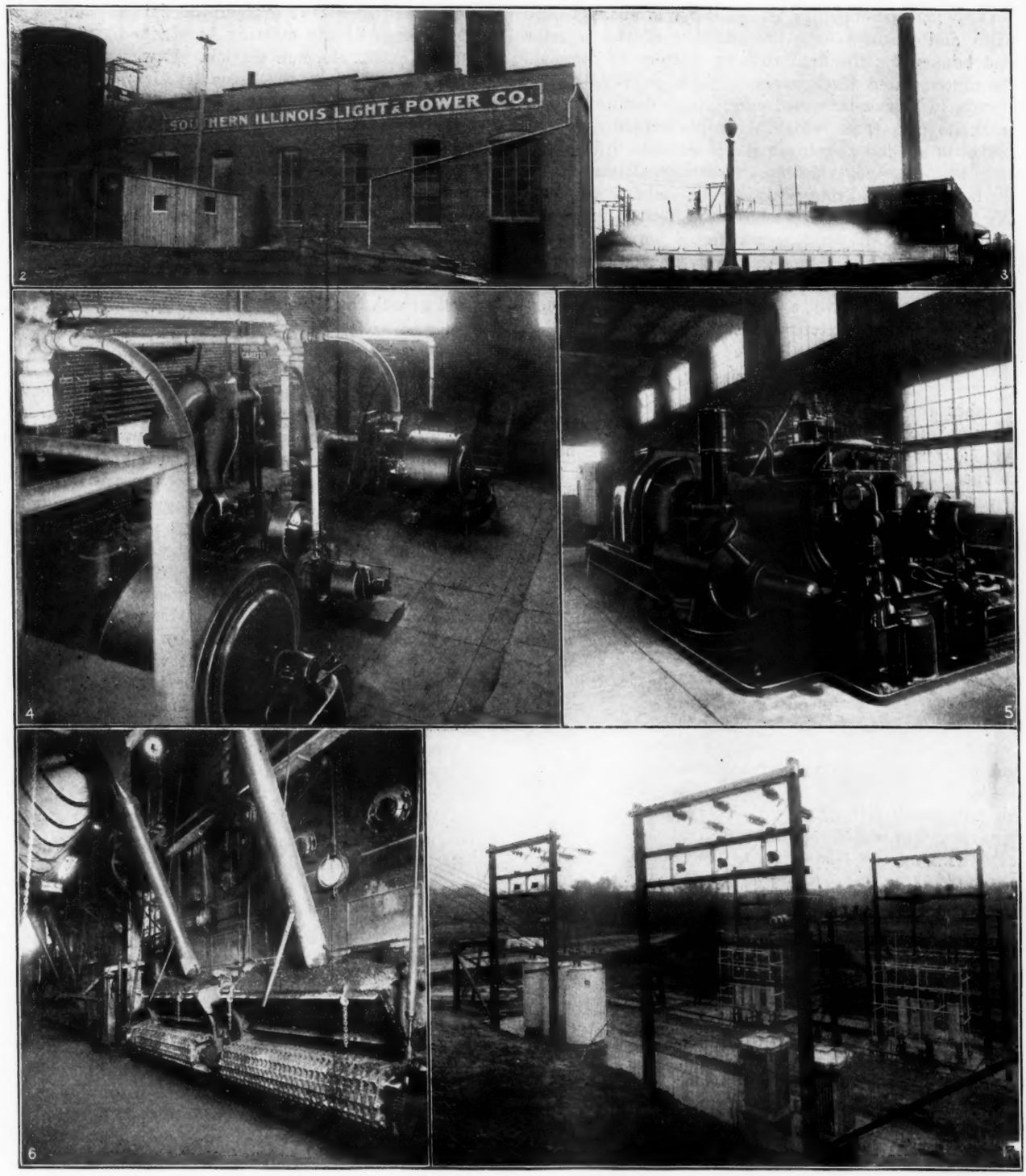


FIG. 1. PRESENT LAYOUT OF PLANT, DOTTED LINES SHOWING PROPOSED EXTENSION



GENERAL VIEWS IN THE COLLINSVILLE PLANT BEFORE AND AFTER RECONSTRUCTION

Fig. 2—Exterior of the old plant.
Fig. 3—Power-plant building rebuilt
Fig. 4—Initial 500-kw. units.
Fig. 5—New 1500-kw. turbo-generator.
Fig. 6—The boiler room.
Fig. 7—Outdoor substation.

Stirling boilers, equipped with chain grates having 80 sq.ft. of active grate area were installed. Foster superheaters provide 75 deg. of superheat at normal rating and 100 deg. of superheat when the boilers are operating at 200 per cent. of rating. The boiler capacity will be increased again when the first 3000-kw. turbo-generator replaces one of the 500-kw. units, a 1000-hp. battery taking the place of the old Lyons boilers. Another battery of the same capacity will be installed when the second 3000-kw. generating unit is put in place. As shown in the general layout, this will require an extension of both turbine and boiler rooms.

A new reinforced-concrete stack, 12 ft. in diameter at the top and rising 203 ft. above the boiler-room floor, now serves the boilers. It is large enough to meet the requirements of the entire proposed installation and, when the boiler room is completed, will be at the center of the plant, with two batteries on either side.

Coal- and ash-handling equipment was added to the plant and requires only the addition of the interior coal bunker for the final 1000-hp. battery to complete the contemplated development. Coal is delivered to the station in hopper-bottomed cars. It is dumped into a track hopper, from which it is discharged into the bucket of a 1-ton skip hoist and is elevated to the level of a belt conveyor running over the coal bunkers in the boiler room. From the hoist the coal is automatically dumped into a chute and rotary feeder delivering onto the belt conveyor and is directed into the bunker by an automatic traveling dumper. The bunker is of the "Ferroinclave" type with a capacity to hold 325 tons of coal, which will be increased to 550 tons when the boiler room is extended for the final 1000-hp. battery.

Ash Removal

Ashes are raked from the hopper under each boiler furnace into an industrial car. Through a tunnel the car is conveyed to the skip hoist, the ashes being dumped into the bucket of the hoist and elevated to a concrete ash bin over the track on which the coal is delivered to the plant. From the bucket the ashes pass through a flapper valve into the ash tank. The motor of the hoist is under push-button control from the tunnel and from the building housing the hoist.

As the new unit carries the load the greater part of the time, condensate from the surface condenser is available as boiler feed, so that it is necessary only to soften a comparatively small amount of makeup water. From the purifier this makeup water enters a 2500-hp. Webster open heater under float control. The heater is mounted on a platform in front of the stack, and a simplex feed pump is located directly underneath. Space has been provided on the platform for a similar installation that will be required when the plant is enlarged. Hand regulation of the pump controls the supply of feed water to the boilers.

Appearing in the foreground of Fig. 3 is the spray pond serving the 1500-kw. unit. Over the outside walls it measures 77 x 130 ft. It is 4 ft. deep and is made up of sloping concrete walls around a clay puddle bottom. The pond is provided with 14 heads of five sprays each, making a total of seventy 2-in. nozzles. There is capacity to cool 2800 gal. of water per minute, the operating pressure on the nozzles being 7 pounds.

The switchboard is equipped with the usual instruments, oil switches and circuit-breakers with automatic time-limit relays. In the outdoor substation shown in Fig. 7 are three 500-kv.-a. and three 200-kv.-a. transformers. Electrolytic lightning arresters and pole-type air break switches are also part of the equipment.

Plant Reconstructed

With the new arrangement of the power-plant equipment and the increase in capacity, it was necessary to reconstruct the building. To accommodate the coal bunkers the boiler-room roof had to be raised and the walls rebuilt. At the same time facilities were provided for tube removals without the necessity of passing them through the roof. In the turbine room the floor had to be elevated above the existing level to provide a basement for surface condensers and as a result it was necessary to increase the height of the new turbine-room walls and to avoid the inconvenience and increased cost of the future changes to raise the roof of the existing turbine room to correspond to that of the new section. It was also decided to take advantage of the reconstruction to make the building entirely fireproof and as attractive as possible and still be consistent with local surroundings. Figs. 2 and 3 show exteriors of the power plant before and after. The boiler-room walls and roof were first removed and in the turbine room temporary shoring was built to hold up the old roof while a new roof was being built over it. The boiler-room roof girders were transferred to support this new roof, consisting of 2-in. reinforced-concrete slabs covered with five plies of felt, tar and gravel, the slabs resting on channel purlins.

Operation Maintained

For three months while this work was going on, the boilers were left out in the open. Steelwork heavy enough to support the coal bunker and the new roof had to be erected on a new foundation under the boiler room and the brick walls rebuilt. The temporary walls and the old roof of the turbine room were removed and the plant was eventually completed as it now stands. Owing to unavoidable delays in the receipt of material and equipment, the period of reconstruction lasted eight months. In all this time there were only two shutdowns and these were necessary for tying in the new with the old work. During this period the load ran up to 800 kw. and was carried by the two 500-kw. units, as the new 1500-kw. machine was not put into operation until February of the present year. The load now averages around 1400 kw., and on occasion when it is necessary to support the Hillsboro plant, it will exceed 2000 kilowatts.

All the necessary instruments are now being installed, so that complete operating data will soon be available. A comparison between the operating costs of the old and the modern station should make interesting reading. W. E. Playter is chief engineer of the plant, and from him was obtained much of the information contained in the foregoing article.

According to *Commercial Reports* the Institute of Victorian Industries, Australia, has approved the utilization of lignite as a source of power. In a report favoring the project, the institute's brown-coal sectional committee recommends that immediate state action be taken to obtain estimates on the cost of a 50,000-kw. plant at Morwell and a similar plant at Altona, with a transmission line, etc., in each case, to opening up and equipping a quarry at Morwell to supply a 50,000-kw. plant and 120 tons of briquets a day; briquetting plant, one press, capacity 60 tons daily; that two experts be sent abroad immediately to investigate latest power-plant practice and equipment necessary to secure full utilization of the vast brown-coal resources.

The capital invested in hydro-electric enterprises in Spain amount to about $300,000,000. Most companies work on comparatively small capital, only six of them being capitalized at over $4,000,000 each. The most important company is located in Barcelona and already supplies about 100,000 hp. In one case current is transmitted at 100,000 volts for a distance of 112 miles and in another at 66,000 volts a distance of 158 miles.

Practical Talks on Controllers—A.-C. Contactor Switches*

A comparison is made between the construction of direct-current and alternating-current electromagnet switches with special reference to the application of the alternating-current switches to an automatic compensator for starting squirrel-cage motors.

THERE are many types of alternating-current motors being manufactured today, but those most frequently used for industrial application are the squirrel-cage and wound-rotor types. The primary, or stator, of these motors is wound two- or three-phase and for voltages ranging from 110 to 6600, but the majority are three-phase and range from 220 to 2200 volts. The secondary, or rotor, circuit is generally three-phase, irrespective of whether the stator is two- or three-phase. Therefore multiphase circuits must be controlled in both the stator and rotor for wound-rotor motors, but in the stator only for squirrel-cage motors. Some of the apparatus that has been designed to meet the industrial requirements for controlling these two types of motors will be described.

The characteristics of the alternating-current contactor are best shown by making comparison with a direct-current contactor. Fig. 1 shows a direct-current type of contactor that was described in the issue of Nov. 21, 1916, and Fig. 2 shows one of the original types of alternating-current contactors. Comparing the two, there will be noted some points of similarity and many of dissimilarity. The arc chute, contact tips and copper shunt are very similar, but the electromagnet and operating coils are entirely different. By referring to Fig. 1, it will be seen that the direct-current electromagnet is built of solid iron, that the magnetic path, where the contactor is open, has only one small air gap *A;* that the armature *B* travel is small and the coil *C* is long. In the alternating-current electromagnet shown in Fig. 3, which is a side view of the magnet *M*, Fig. 4, the core *D* is made of laminated iron; the magnetic path, when the contactor is open, has two large air gaps *A*, the armature *B* travel is large and the coil *C* is flat. The question naturally arises regarding the reason for this difference.

The power input to a shunt direct-current contactor is a function of the coil resistance only and is independent of the position of the armature or the length of the magnetic air gap. Therefore, since the power input is constant, the magneto-motive-force (m.m.f.) is constant and the torque tending to close the armature varies inversely as the square of the length of the air gap. Also, the coil has to be large enough to dissipate continuously the necessary power input, and to keep this as small as possible it is essential to have a small air gap.

The power input to an alternating-current contactor is primarily a function of the reactance of the coil, and the reactance is a function of the magnetic air gap. This means that if the air gap is increased, the power input to the coil is increased, and in this way the m.m.f. across the air gap increases and tends to counteract the increased resistance to the magnetic lines of force across the air gap. As the contactor armature closes, the power input decrease is such that when the armature has completely closed, only about one-fifth the initial rate will be taken continuously by the coil.

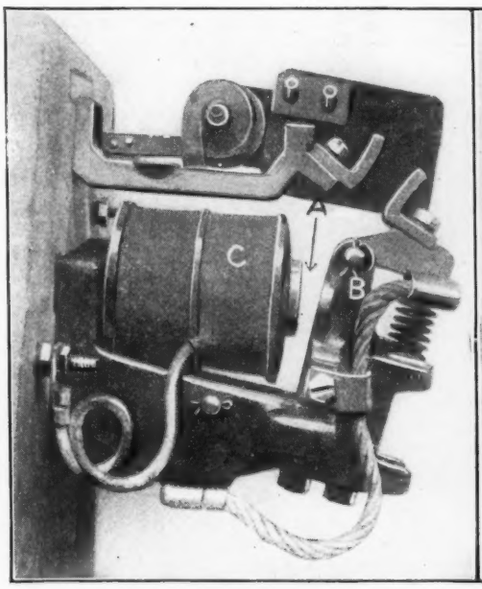


FIG. 1. DIRECT-CURRENT TYPE OF CONTACTOR

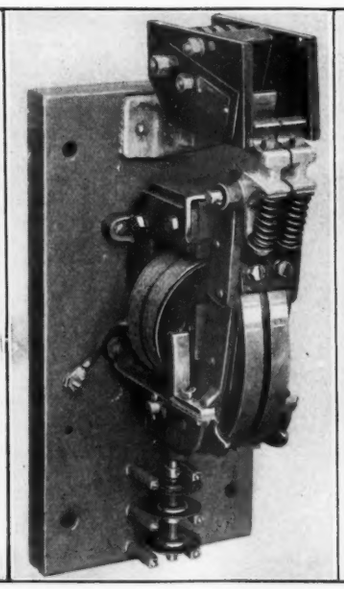


FIG. 2. ORIGINAL TYPE OF A.-C. CONTACTOR

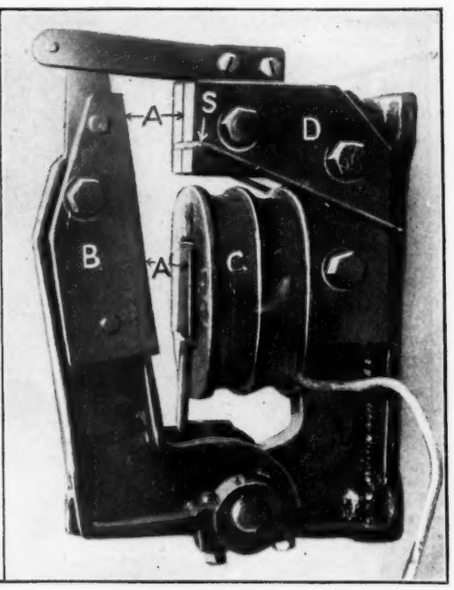
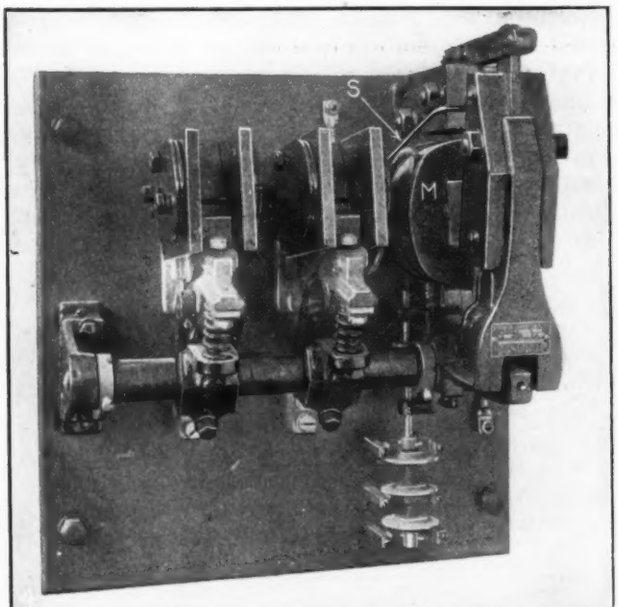


FIG. 3. MODERN TYPE OF ALTERNATING CURRENT CONTACTOR

*The material in this article was contributed by B. W. Jones, industrial control engineer, General Electric Co.

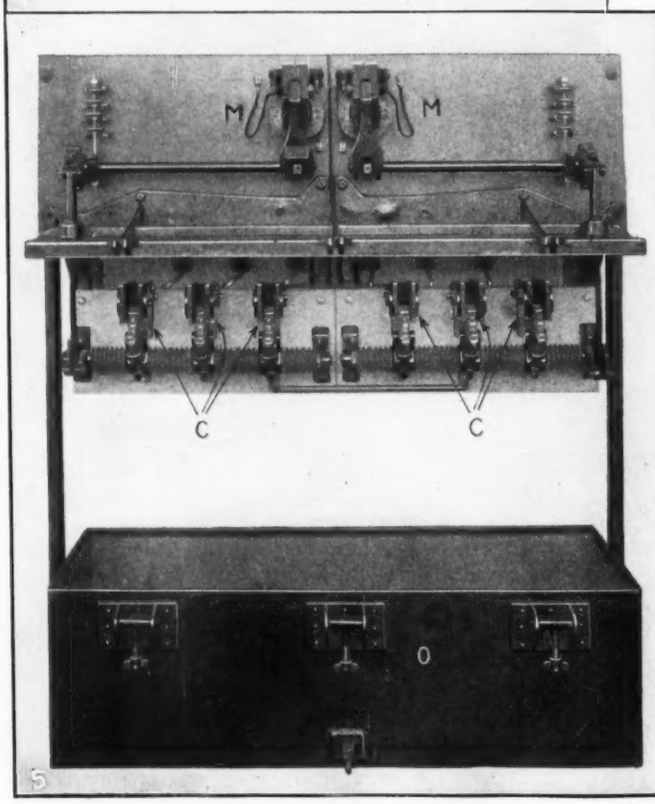
The flux in a direct-current contactor is uni-directional, and therefore there is no tendency to chatter; whereas, the flux in an alternating-current contactor reverses at every alternation, and while passing through zero, the armature tends to rapidly open and close, producing chattering.

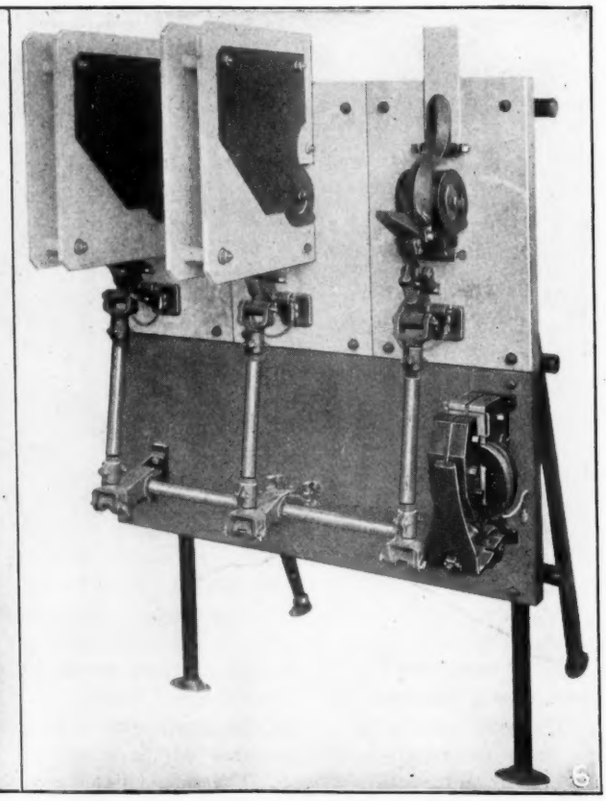


To obviate this, the armature is designed to complete the magnetic path, when closed, of the U-shaped electromagnet with very small amount of air gap in circuit, and an out-of-phase flux is used to hold the armature in while the main flux is passing through the zero point. This out-of-phase flux is produced by the current induced in a bar, known as a "pole shader" *S*, which is embedded in the face of the polepiece *D*, as shown in Figs. 3 and 4, and short-circuited by a strip of german silver on the back of the panel, giving a path of low resistance. Therefore, the alternating-current contactor, when open, has two magnetic air gaps *A* and *A*, Fig. 3, so as to eliminate unnecessary air gaps when closed. It has a large armature travel because it does not impair the operating features, but on the other hand is used to advantage; and it has a flat coil because the coil power loss is not large after the contactor closes, therefore does not need a large radiating area.

As shown in Fig. 2, the original type of alternating-current contactor was single-pole, but since alternating-current motors require two or more contacts to disconnect them from the line or to short-circuit the starting resistance, the later types have been made multipole, as shown in Fig. 4. The principles of design are the same as the single-pole, but the mechanical details are different. This style has been adopted quite generally by many manufacturing companies as their standard. The General Electric Co. builds them in current capacities ranging from 25 to 1500 amperes with each size having single, double and triple poles and some forms having four poles.

When the power voltage is 2200 or higher, a different construction is necessary. Contactors are made which break and make the circuit under oil or in the air. If under oil, then parts of the standard low-voltage air-break contactors are assembled, as in Fig. 5, which shows a front view of a triple-pole reversing contactor panel. The contactors *C*, electromagnets *M*, and oil





FIGS. 4 TO 6. SHOW TYPES OF ALTERNATING-CURRENT CONTROL CONTACTORS

Fig. 4—Two-pole low-voltage a.-c. contactor

Fig. 5—Triple-pole, high-voltage, oil-immersed, reversing contactor panel

Fig. 6—Triple-pole, high-voltage, air-break, a.-c. contactor panel

tank *O* are indicated on the figure. If air-break, the dimensions of the contact parts and arc chutes are greatly increased and a somewhat different construction is used, as shown in Fig. 6.

The high-voltage oil-immersed contactor, in general, is cheaper than the air-break contactor, but its fields of application are limited. It should not be applied where the service requires more than fifteen operations per hour because the arc is so concentrated under oil that it causes the tips to burn more rapidly than when in the air, and the oil to become carbonized, which in time will cause a flash-over unless the oil is kept clean. The air-break contactor has no operating limits and can be used on any rapid-service cycle, such as a mine hoist. The type shown in Fig. 6 has proven its ability to perform long and severe duty cycles with very few repairs.

The contactors just described will close and open the power circuits whenever their operating coils are energized or deënergized, but they have no inherent characteristics to make them select the proper time to close or open in order to function correctly when automatic operation is desired. To obtain the latter characteristic auxiliary devices, known as current-limit relays, are required. Figs. 7 and 8 are two views of one type of relay which is generally used with squirrel-cage-motor control, and Fig. 9 is essentially the same relay but with a disk *D* in place of the lever contact *L* at the top. This latter form is generally used on panels which control rotor-wound induction motors.

Figs. 7 and 8 show this type of relay to have: A shunt coil *S*, with a large number of turns; a series coil *C*, with a few turns; a movable plunger *P*, in each of these two coils; a walking beam *B*, between the two plungers; a lever contact *L*, at the top of the series-coil plunger; and the magnetic frame *F*, which is used as the support for all these parts. The front plunger is connected to the walking beam, but the back plunger only rests on it. The leverage is such that the front plunger overbalances the back plunger, and the normal position is that shown in Fig. 8. When the shunt coil is energized, its plunger together with the front end of the walking beam, is drawn up and the back plunger is free to drop, as shown in Fig. 7. However, if sufficient current had been flowing through the series coil, its plunger would be held up magnetically against gravity and not allowed to drop until the current in this series coil had decreased to a value determined by the calibration of this plunger. The plunger of the series coil is made of two half-cores connected by a brass rod, one core being rigidly connected and the other threaded on the brass stem in such a way that these two half-cores can be brought together or separated with quite an air gap. When together, it takes less current in the series coil to hold the plunger up than when separated. Turning the adjusting nut *N* at the bottom of the plunger varies the air gap and therefore the current calibration. This calibration range is two to one, which means that if the minimum calibration is 2000 ampere-turns, the maximum would be 4000 ampere-turns.

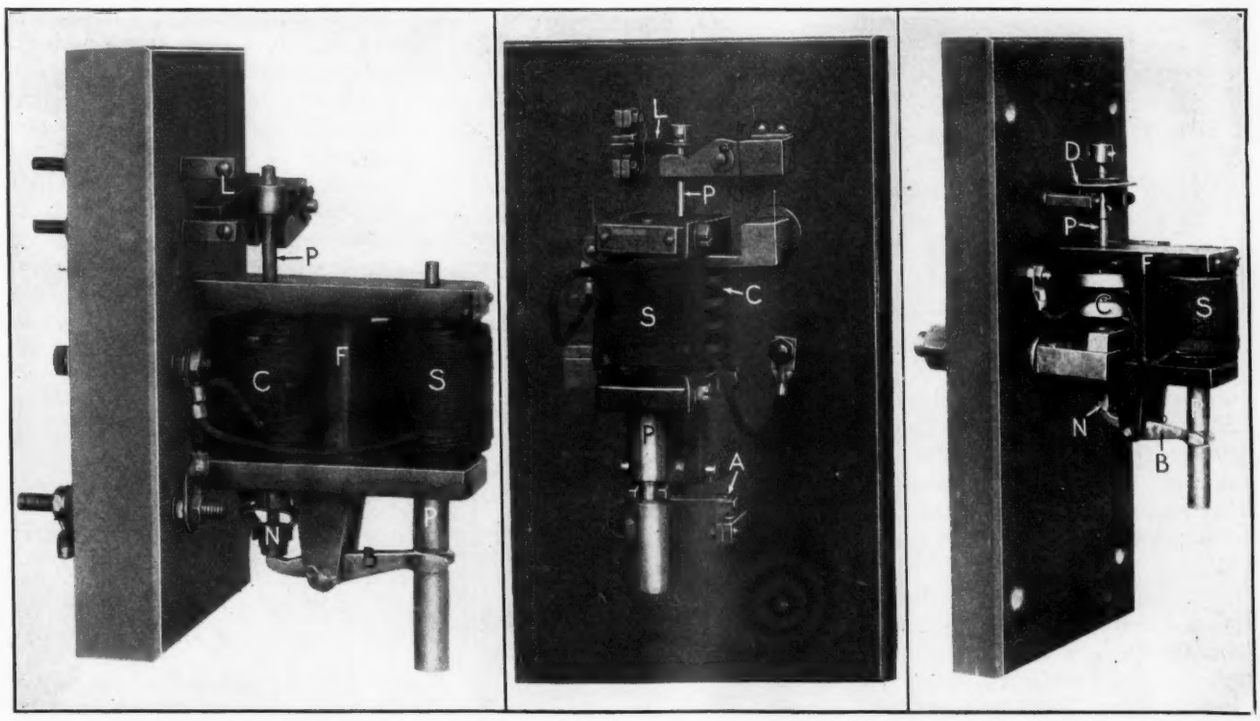


FIG. 7. SIDE VIEW OF SQUIRREL-CAGE-MOTOR CONTROL RELAY

FIG. 8. FRONT VIEW OF SQUIRREL-CAGE-MOTOR CONTROL RELAY

FIG. 9. WOUND-ROTOR-MOTOR CONTROL RELAY

The relay shown in Fig. 9 is the same as that shown in Fig. 8, except that in place of the lever contact *L* at the top, a disk contact *D* is substituted. Also on certain forms of the Fig. 8 type, an auxiliary normally open contact *A* is added at the bottom for use on automatic compensators. It is closed by the back end of the walking beam forcing it down into contact when the shunt coil is energized and its plunger drawn up.

By means of the multipole contactors and current-limit relays, various kinds of automatic-control equipments can be designed.

Fig. 10 shows an automatic compensator used for starting a squirrel-cage motor. It consists of an open-delta auto-transformer, one starting contactor S, one running contactor R, and a current-limit relay D, which controls these two contactors. Figs. 11 and 12 are schematic diagrams of the main circuits of a standard

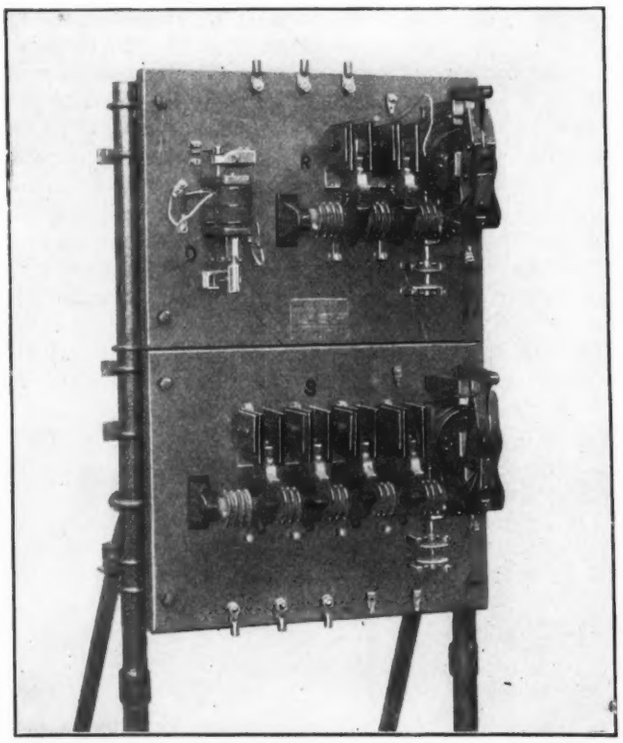


FIG. 10. AUTOMATIC COMPENSATOR CONTROL PANEL

automatic-compensator panel which shows the starting and running connections. They are self-explanatory. The contacts marked S in Fig. 11 connect the compensator to the line and the motor to the compensator. This connection gives partial voltage for starting the motor; the direction of the current at one instant is indicated by the arrowheads. Fig. 12 shows the four contacts marked S open and the two contacts marked R closed, a combination which disconnects the compensator from the line and applies full line voltage to the motor. Opening the four-pole and closing the two-pole contactor is accomplished by means of a current-limit relay D, shown in Fig. 10.

Fig. 13 gives a complete connection diagram for the automatic compensator in Fig. 10. Closing the control switch and assuming a line polarity as shown, the current will pass from the L_2 terminal to P, down to the control switch, back to C_1 on the control panel, and up to and across the relay contact 1-1 on the current-limit relay D, down through coil Y on the four-pole contactor S, up and across the top disk 6 of the interlock on contactor R to the L_3 side of the line, as indicated by the arrowheads. This will energize coil Y and cause it to close the four-pole contactor switch S, which will in turn open disk interlock 3 and close 4, as shown in Fig. 14. Closing interlock 4 will close the circuit through the shunt coil Z of the current-limit relay D. The circuit for coil Z is from terminal a, through the coil to b, down to 4, through the disk contact to terminal d on coil Y, and to the negative side of the line, as indicated by the arrowhead. Energizing this coil will cause it to pull up its plunger and close the auxiliary contact 5, and thus make a holding circuit for itself from b, through 5, to disk contact 6 on switch R, and to the negative side of the line, as shown in Fig. 15.

Referring to Fig. 14, the motor circuit is from L_2, through the series coil X, and around through contact g on switch S, to the B terminal on the compensator, to terminal h, and back to contact h on the starting switch to T_1 on the motor. In the motor the circuit divides and comes out to terminals T_2 and T_3. From T_2 on the motor the circuit passes direct to T_2 on the panel board and to L_1 terminal of the line. The other side of the circuit T_3 passes up to terminal T_3 on the panel board, to contact f, and then to terminal f on the compensator winding, through a section of this winding to B', to contact e, around to the line terminal L_3, as indicated by the arrowhead.

In this case the current from the secondary f-A', combines with that in secondary h-A, and passes with the primary current down through contact h and into the motor, where it divides with the primary current, part of it coming to T_2 and part of it to T_3, on the panel board, and around to A and f respectively, on the compensator.

When the motor accelerates the current will decrease to about normal value, and the plunger in the series coil X of the current-limit relay D will drop, breaking contact across 1-1 and making contact across 1-9, as shown in Fig. 15. This will open coil Y circuit on contactor switch S and cause it to open, thus opening the interlock contact 4 and closing 3. The circuit is now closed through coil W on contactor switch R, from a on coil Z, across relay D, contacts 1-9, down to 3 interlock on

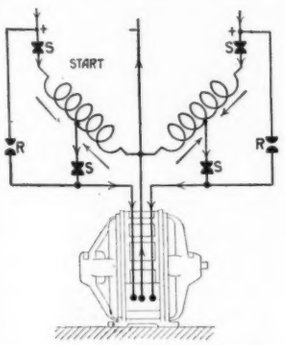


FIG. 11. COMPENSATOR IN STARTING POSITION

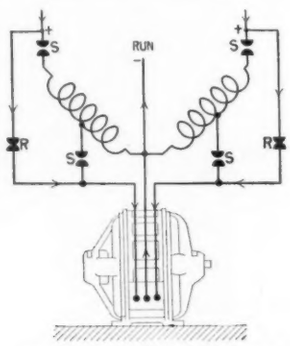


FIG. 12. COMPENSATOR IN RUNNING POSITION

switch S, up to 7 on contactor switch R, then to terminal j on coil W, through the coil to k and to the L_3 side of the line, as shown by the arrowhead. Energizing coil W will cause contactor switch R to close, as shown in Fig. 16. As soon as contactor switch R closes, its interlock 6 opens and 7 closes. This disconnects the shunt coil Z on the current limit relay D, from one side of the line, and also makes a holding circuit for coil W, through 7, as indicated.

The closing of contact switch R connects the motor direct to the line, the circuit being from terminal L_2, through contactor m, down direct to T_1 on the motor, into the motor, where it divides and comes out to terminals T_2 and T_3. From terminal T_2 the circuit is directly to L_1, and from T_3 to the bottom of contactor f on switch S, which is now open, up through contactor l on switch

R, and to L_3. The motor is now up to full speed with line voltage applied to its terminals, this speed being practically constant for all loads.

The reader must not overlook the fact that this is a three-phase alternating-current circuit, and that the circuits are traced out on an assumed instantaneous polarity. At another instance different conditions of polarity would exist, and the circuits will have a different direction; nevertheless, if they are correct for one polarity, they are correct for any condition that may arise in the circuit.

[*The next article will treat of controllers, both of the manual and automatic type, for starting wound-rotor, alternating-current motors.*]

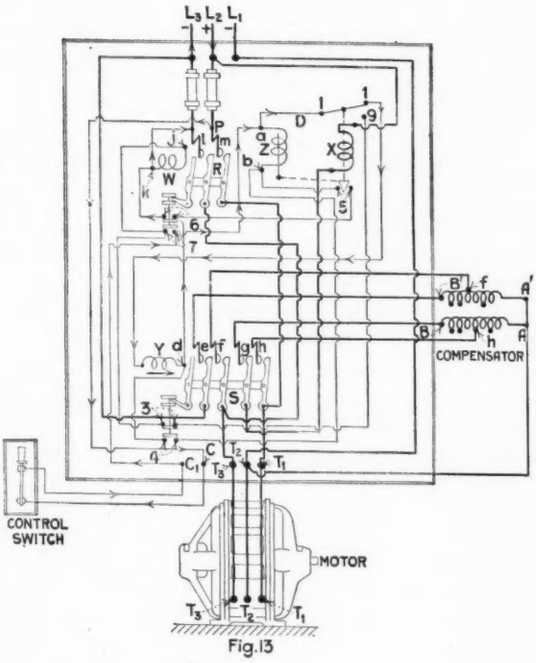


Fig. 13

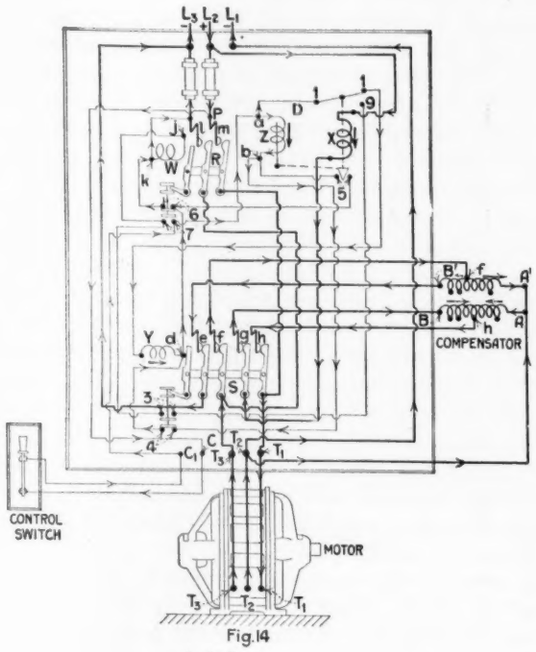


Fig. 14

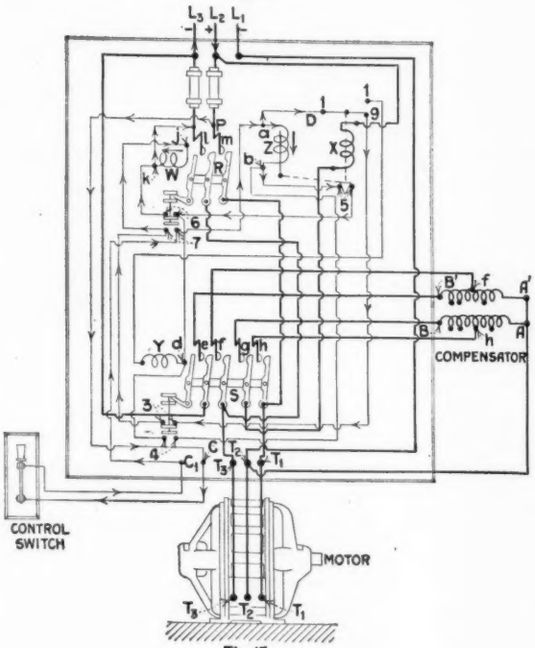


Fig. 15

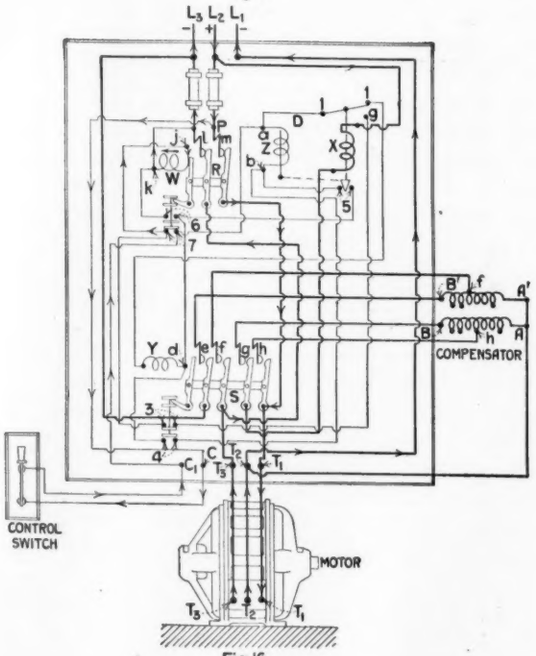


Fig. 16

FIGS. 13 TO 16. WIRING DIAGRAMS FOR THE COMPENSATOR SHOWN IN FIG. 10

The Lubrication of Gears

BY H. R. SMITH

One of the primary difficulties in lubricating gear sets is the fact that the contact does not occur over a surface, but on a line. There is no opportunity for the construction of an oil film as in a bearing, on a cylinder wall or crosshead guide. The increased difficulty of preventing friction can be readily imagined therefore when only this fact is considered.

In analyzing the motion of one gear tooth relative to another, we find that there is a combined sliding and rolling action taking place along the flank of the tooth and perpendicular to the axis of the gear. The lubri-

cant, to act as a cushioning and protective medium for the surfaces, is required to stand up under a resulting force, tending to press it from between the teeth in contact and toward the root of the tooth on the driven gear. In the case of bearing lubrication, the journal in rotating drags the oil from the area of the bearing under minimum pressure to the area under maximum pressure and builds up the film between the acting surfaces by doing so. In the case of gears, however, the flanks of the teeth do not act over their entire surface, but on a line extending the length of the tooth, and under these conditions the dragging action is lost.

In applying an oil or semifluid grease, the gears may be fitted with a bath of oil or thin grease into which the lower parts of the gear project and in rotating, carry the lubricant around to the point of contact. This method is more applicable to fairly large installations than to small automobile transmissions and differential units where the whole casing may be filled with a soft grease and the gears run completely covered, with precautions against leakage. In large installations it is good practice to have the oil flow through feed pipes to a point over the contact point of the gears, distributing it through numerous small holes along the whole width of the gears. This is termed the forced system of lubrication in which the contact surfaces are flooded and the oil is used over and over again. The most difficult problem occurs when the gears are not contained in a casing suitable for a bath, packing with soft grease or forced-feed systems. In cases of this kind the gears are lubricated by hand-applied oil or grease according to the speed of rotation, pressure on the tooth and external conditions.

Centrifugal Force Throws Lubricant Off

Another factor to be considered is the tendency of the gears to throw off the lubricant by centrifugal force and increased by the velocity of rotation, but partly offset by the tendency of the oil to collect at the outside edges of the teeth, where the initial action of the lubricant is most required, whence it is forced along ahead of the line of pressure on the teeth of the driven wheel, while that on the edge of the teeth of the driver lubricates the root of the driven tooth.

In the case of force-feed or flood lubrication it is preferable that the oil have a high specific heat to make possible the rapid absorption of heat generated by the friction of the gears.

On account of the high cohesive and adhesive properties, a heavy oil is well adapted for the lubrication of inclosed gears where a bath is used into which the bottom of the gears project, as it will adhere to the gears better, under high speed than the light oil. The tendency is for the lighter oil to be thrown off almost entirely before the point of contact is reached, while enough of the heavy oil is retained on the teeth to serve as a lubricating layer. At higher speeds the tendency to throw off the oil is greater. It is a matter of judgment, however, the oil being selected accordingly, not forgetting the probable running temperature.

Where the oil is fed through a row of holes above the point of contact directly onto the gears when they are about to mesh, the tendency to be thrown off is not considered important and pressure on the tooth more than any one factor determines the body of the oil to be used and the velocity is considered more from the standpoint of the relative velocities of the tooth particles sustaining the acting pressure. The higher the velocity of the contact areas, the lighter should be the oil used, so that this condition points to the use of a low-viscosity oil. It is probable that this system is to be used on a high gear ratio where the speed of the pinion is very high and the tendency to heat is much greater than on small reductions; and as lighter oils have the ability to carry away more heat and the system constantly supplies a large quantity of oil, a lighter oil is preferable to one having heavy "body."

In the case of rolling-mill gears and those exposed to the weather, as the gears used on drying kilns and the like, the problem of selecting a lubricant requires special attention in each particular case and it is only possible here to consider their lubrication from the mechanical standpoint with the exterior conditions normal, for separate treatment of each case would require too much space. Gears of this type are generally operated at relatively low peripheral speeds, but often sustain high tooth pressures. The velocity is sufficient, however, to cause the light oil to be thrown from the teeth, and as no means are used to collect this oil, it is a complete loss. On account of the high pressures and for the purpose of economy, oil of a medium or heavy body or a grease should be used, the mechanical characteristics as to size, speed and pressure determining the properties of the grease. Various thick viscous distillation-residue compounds have been used with satisfaction for this purpose. It might be stated, though, that these semisolid lubricants have one disadvantage in so far as they become contaminated with grit and dirt which are retained in the grease and act as abrasives upon the gears, causing excessive wear. It is necessary, however, that the grease should "stay put," as applications are made by hand and very often at none too frequent intervals. A grease satisfies these conditions in its physical properties much better than oil.

It is of primary importance in lubricating problems to consider the running temperature and select a lubricant according to the viscosity at this temperature, and the qualities mentioned must refer to the normal operating temperature.

The Autogenous Welding Committee of the American Society of Refrigerating Engineers has been appointed and consists of the following members: F. L. Fairbanks, chairman, chief engineer Quincy Market Cold Storage and Warehouse Co., Boston, Mass.; Lewellyn Williams, engineer York Manufacturing Co., and Shipley Construction and Supply Co.; S. F. Jeter, chief engineer Hartford Steam Boiler Inspection and Insurance Co.; P. A. E. Armstrong, metallurgical engineer, the North American Co.; Charles H. Bromley, associate editor *Power;* James C. McCabe, engineer, Department of Safety, Detroit, Mich.; Theo. Vilter, president Vilter Manufacturing Co., Milwaukee, Wis.; Prof. Edward F. Miller, Massachusetts Institute Technology; John E. Starr, consulting engineer, New York, and Thomas Anderson, refrigerating inspector, City of Chicago.

The purpose of the committee is to assist in the development of the welding art and to make its application to pressure vessels as safe as the best knowledge of the subject can make it; see editorial page.

Tom Hunter, Hoisting Engineer

By WARREN O. ROGERS

We visit a mine where the mechanical equipment was operated by electricity, a part of which was generated at the company's hydro-electric plant. Hunter explains the advantages of operating the skip hoist by direct-current motors. A motor-driven generating set is necessary with such a hoist, and its operation is explained. Some interesting recording devices are seen, which are of value in checking delays in hoisting.

WHEN we arrived at the Negaunee mine, we found that everything was operated by electricity even to the hoisting units, and a boiler plant was among the missing.

"Where do they get their electrical energy?" I asked, noticing the absence of all kinds of steam equipment.

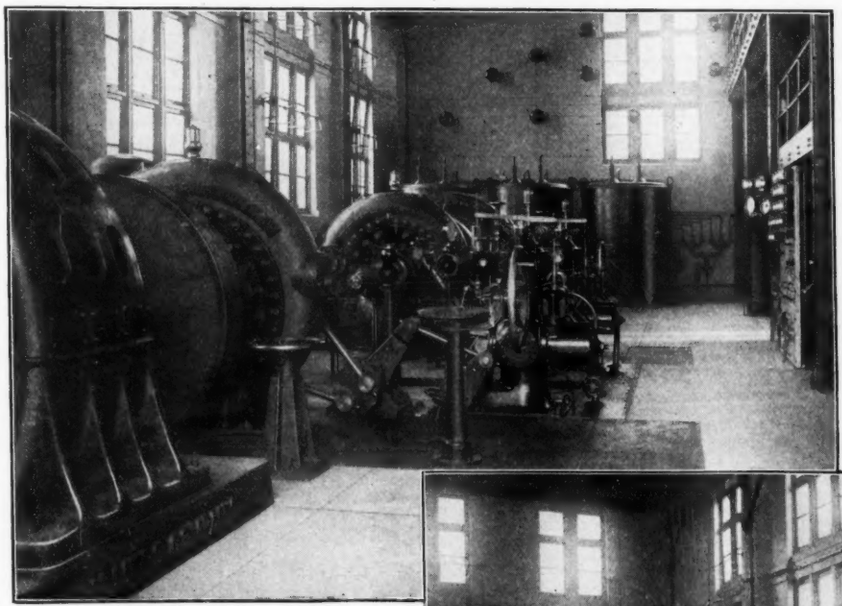


FIG. 1. TURBO-GENERATOR, TRANSFORMERS IN DISTANCE

"Some of it is generated by steam plants and some by a small hydro-electric power plant on the Carp River, near Marquette. We will take a run down there tomorrow and look it over."

This program was followed out, and the water-power plant was inspected the next day. We were told that it was the first and only water-power plant in the mining section in that part of the state and that another development was being put in. Figs. 1 and 2 show what kinds of units we found there. There were two 2800-kw. 2300-volt three-phase 60-cycle generators running at 720 r.p.m. Each was driven by a 4000-hp. turbine waterwheel working with a 550-ft. head. At one end of the turbine room were the transformers, through which the 2300 volts at the generator was stepped up to 30,000 and sent to Ishpeming, 36 mi. distant, over No. 2 copper duplicate transmission lines. The speed of the generator waterwheels was regulated by oil-controlled governors. Each unit was equipped with an exciter on the generator-shaft extension.

At one side of the hoisting room of the Negaunee mine was a Nordberg air compressor (Fig. 3) driven by a synchronous motor of 325 hp. at 120 r.p.m. The air pressure maintained was between 75 and 80 lb.

"I want you to notice the main hoisting equipment," said Hunter.

"What about it?" I asked, looking first at one and then at the other. "They are both alike except in size."

"That is where you are wrong. The man and supply hoist (Fig. 4) is driven by a 200-hp. 200-volt direct-current motor at 250 r.p.m. at full load. The drive between the motor and the 10-ft. diameter drum is by herringbone gears. Now the 8-ft. diameter drum of the main skip hoist (Fig. 5) is directly driven by a 500-hp. direct-current motor using 525 volts and working at 60 r.p.m. at full load. So you see that one hoist is gear-driven and that the other is directly driven by the motor."

"Well, I hadn't noticed that. More than that, I supposed that all large mine motors were of the induction type."

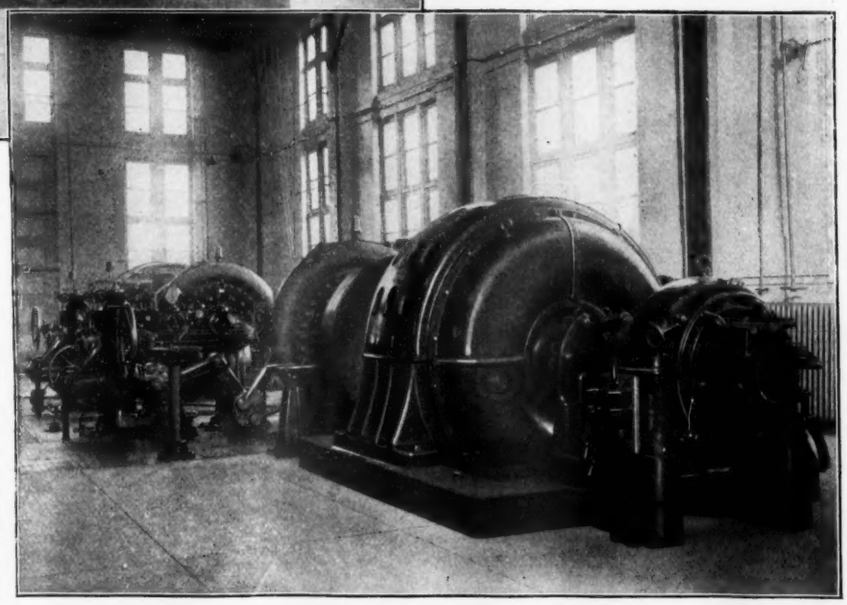
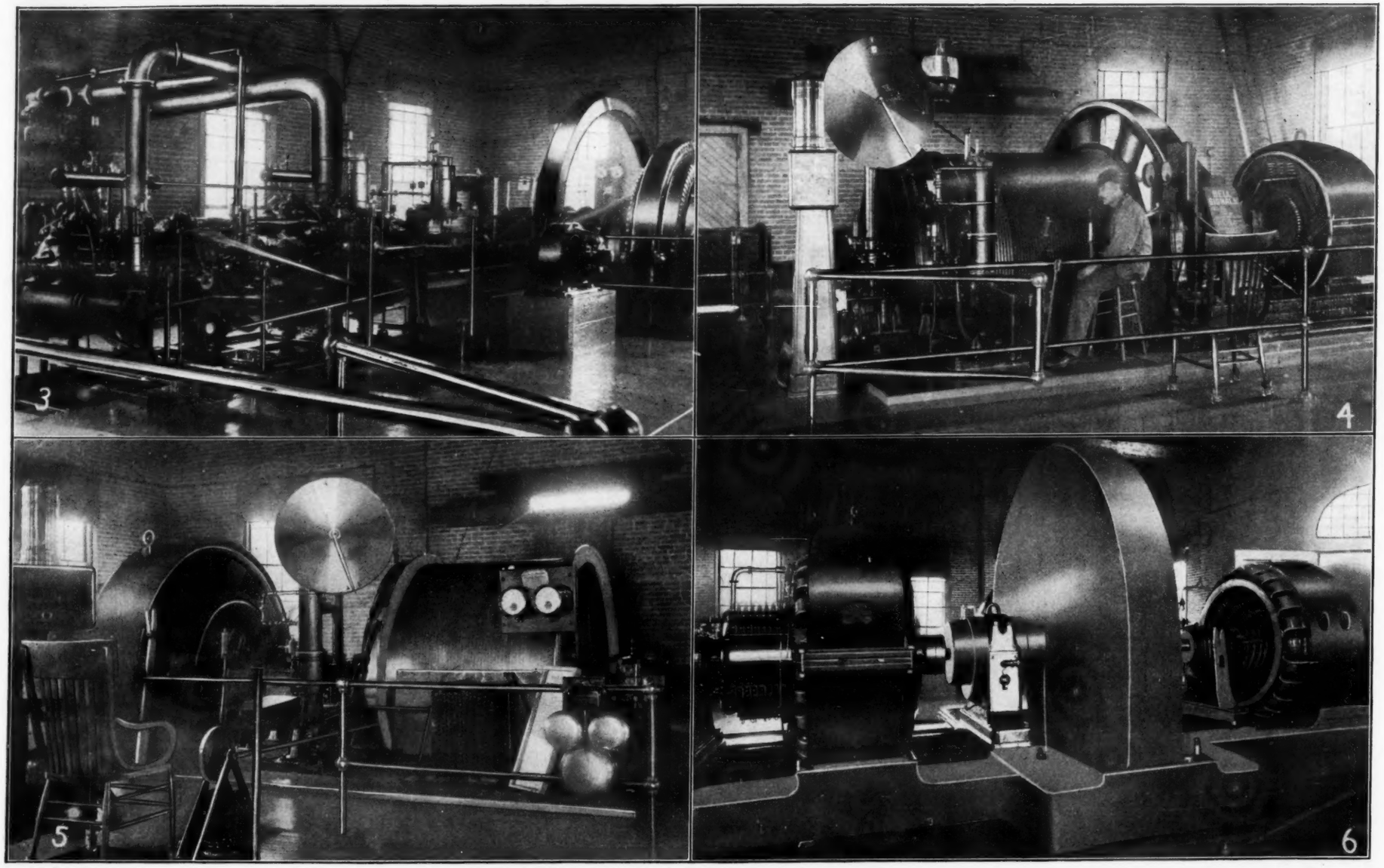


FIG. 2. TWO 2800-KW. TURBO-GENERATORS AND WATERWHEEL GOVERNORS

"Mine hoists," rejoined Hunter, "are practically of two kinds—direct-current motors, operated from their



FIGS. 3 TO 6. SOME OF THE APPARATUS FOUND AT THE NEGAUNEE MINE

Fig. 3—Air compressor driven by a synchronous motor. Fig. 4—Man and supply hoist, motor driven, geared connection. Fig. 5—Main skip hoist directly driven by a 500-hp. direct-current motor. Fig. 6—Motor-generator set

own motor-generator sets, and induction motors. The direct-current equipment with generator field control is frequently used with the motor directly connected to the drum shaft, because of the slow speed at which it runs. Such a unit will cost more than a geared outfit, but that is largely offset, in some cases, by the saving in gearing, wear and tear, etc. There are circumstances, however, where the mechanical advantages of the direct-connected motor are not of importance, and in such a geared motor should be used. Induction motors are also used, but they are generally of the geared type, although it is practicable to use the direct-connected induction motor for large-capacity hoists at high rope speeds, using a small drum."

"How is it that there are not more motor hoists? It looks to me as if the motor was far ahead of the steam-driven outfit. There are no boilers or steam-pipe leaks with water dripping over everything, and what is more, they occupy less floor space, which would cut the cost of the building housing the hoist."

"Sure thing," answered Hunter. "An electric hoisting equipment is better than a steam hoist when considered with a new mine, but when it comes to scrapping a lot of steam machinery that is good for years to come for hoisting purposes, there is another story to tell, although there are many cases, to my way of thinking, where the increased economy derived by electrical operation is enough to have a lot of weight in getting rid of many of the steam hoists I have seen."

Electric Hoist Speed Control

"How do they control the speed of these electric hoists? I don't see that they use the brakes much."

"Well, you see, with the ordinary types of motor hoists the speed and direction of rotation are both controlled by the same lever. To operate a hoisting engine there is a reversing lever, brake lever and a throttle for the operator to manipulate. You can see that the motor hoist has the best of it in respect to handling, in an emergency at least, in that there is but one lever to handle. Now the speed of an induction motor can be varied by changing the position of the controller. The hoisting of a skip of ore can be retarded and brought to rest by reversing the motor, similar to the 'plugging' of a steam hoist; and when lowering a load out of balance at a speed a little above synchronism, the motor can be used to limit the lowering speed by returning energy to the line. On the general type of motor hoists the speed varies with the position of the controller, but on a given position of the controller the speed is nearly the same for wide variations of load, from motor overloads to regenerative overloads. For instance, if the controller is gradually moved to the off position, the hoist will be retarded and brought practically to rest; if the controller is brought back to an intermediate position, the hoist will be retarded to a corresponding intermediate speed. In lowering an unbalanced load the speed may be from full rope speed to a very slow lowering speed without the use of the brake. Of course any number of control points can be provided on the controller.

"Moreover, because of these conditions of service the speed characteristics of a direct-current motor with generator field control are just the thing for mine-hoist operation."

"What do you mean by generator field control?" I asked, as we turned to look at a machine composed of a motor, three generators and a flywheel all on one base (partly shown in Fig. 6). The induction motor was of 350-hp. capacity at 690 r.p.m. A 400-kw. direct-current generator supplied 525-volt current to the motor of the main skip hoist, a smaller direct-current generator of 150-kw. capacity supplied 200-volt energy to the motor on the main hoist. The third, a 125-volt generator, was the exciter to the fields of the direct-current generators.

Flywheel Generator Set

"This," said Hunter, pointing toward the combination set, "is a method employed in which a flywheel is used on a motor-generator set for driving a direct-current hoisting motor, and as a matter of efficiency and convenience of control the generator field is used for controlling the hoisting motor. You know it is always best to have a uniform load on a machine if possible, and that also applies to a power plant. Now, in hoisting iron ore the load is not steady and high peaks occur. By making the motor-generator set with a flywheel, energy can be stored in and taken from it in such a way that the motor of the set draws an almost uniform load from the line supplying it. Now, as energy can be taken from and put into a flywheel by varying its speed, it is necessary to use a motor that can be easily adjusted within narrow limits, and an induction motor fills the bill, the larger sets having phase-wound rotors.

"Some form of regulator is used with these machines so that when the line current becomes greater than some set value, a resistance is brought into use on the secondary circuit of the main induction motor and the flywheel set will slow down without taking any excess input. When the flywheel slows down, it delivers its excess energy, which relieves the induction motor of the peak load. When the hoist load has so lessened that the input tends to drop below the set value, the regulating device causes the resistance to decrease and the speed of the set is increased, the input of energy being stored in the flywheel to be given up again when another hoisting peak occurs. Just watch the ammeter of the main skip hoist and see how the energy consumption varies with the load."

Amperage at Peak Load

I walked over to the hoist ammeter and noticed that when starting with a loaded skip from the bottom of the mine, the instrument registered 1200 amperes and gradually dropped to 600 at the top of the hoist. This gives a good idea of what Hunter meant by peak load. The rheostat of each hoist was operated by a lever, and the air-operated brake was controlled by another lever.

"The signal system used here is different from any we have seen." (See left of Fig. 4.) "It is a German make and has an electric gong at the bottom. At the top is a glass, back of which is a light. If the hoist operator is not sure that he has heard the gong signal correctly, he looks through the glass to see what it records. For instance if three bells, dash, one bell has rung on the gong, there will be shown three lights together and one separated from them. A paper ribbon is operated by a clock movement, and it is perforated

for each stroke of the gong so that there is a record of all signals given from the mine to the hoist operator.

"You can see," said Hunter, "that this arrangement makes it quite sure that the operator will get the correct signal. If an accident occurs, there is no chance for an argument in case of a misunderstanding of signals, as the perforated paper record indicates just what signal was given and the exact time."

"Say, the Cleveland-Cliffs people are pretty near being It in their equipment, ain't they? Their machines seem to be about the best that can be had," I exclaimed, as I examined the signal system.

"You are right there," replied Hunter. "You remember we were at the Salisbury mine; well, I forgot to call your attention to a hoist recorder, which I understand was developed by the company. The purpose of that device is to make a record of the movement of the skip for each shift of 12 hours or less. It shows the time used in moving the skip from one level to another, records all delays in hoisting, the period of time lost and at just what point in the mine the delay occurred. It also records the number of skips hoisted from each level and the total number of loaded skips hoisted daily. There is an electric signaling system attached to the machine, so that the various signals are recorded.

"The device has two drums, one being driven by clockwork and winding a strip of paper from the other drum. While the skip is idle, a horizontal pen mark is made on the recording strip, showing whether it is at the top of the shaft, at the bottom or at some level. The pen mark made during hoisting or lowering periods is on a vertical slant, depending on the speed at which the skip is moved. So you see that every movement of the skip up or down and its position when at rest are recorded, together with the signals given and the exact time of giving them, also all delays and whether they are caused by the hoisting man or by the underground workers. The chart is made with the various levels indicated so that reading it is a simple matter. The record of the signals given also shows just where the skip was when the signal was given."

As we left the Negaunee mine, it was getting dark, and after waiting for a street car for some time, we finally reached the hotel, glad to get in out of the cold.

Steam Engineer's License Examination—XIII

By H. F. GAUSS

A simple discussion of the steam turbine, explaining the need for velocity or pressure staging, the action of steam expanding through a nozzle and the conversion of heat into work.

THE steam turbine may be defined as a machine designed to utilize the heat energy of steam by converting it first into the kinetic energy of the moving jet and in turn utilizing the energy of the steam to impart movement to rotating wheels. The turbine consists primarily of a stationary element, including a set of steam nozzles, and a rotating element consisting of a wheel carry buckets on its periphery, into which and against which steam is discharged from the stationary nozzles. As will be described later, a turbine may include a number of successive stationary and revolving elements, and the stationary elements may be expanding nozzles or the expanding nozzles may be carried by the rotating elements.

If steam under pressure is allowed to expand through an orifice or nozzle into a medium at a lower pressure, it will attain a velocity which depends on the initial and final pressures as well as on the design of the orifice or nozzle. In its initial state in the boiler, the steam contains a certain amount of energy; that is, it can do a certain amount of work. It has acquired this energy by virtue of the fact that heat has been imparted to it, and heat and mechanical energy are mutually convertible; in other words, for the expenditure of a given amount of work there is a definite heat equivalent, and for a given amount of heat there is a definite work equivalent.

If steam is allowed to expand in an engine cylinder and push a piston along, it does work, and it does this work at the expense of some of the heat energy it contains. In a perfect engine the number of B.t.u.'s given up by this steam multiplied by 778 (the number of foot-pounds of work to which a B.t.u. is equivalent) will equal the work done in foot-pounds. On the other hand, if steam is allowed to expand through a nozzle, it attains a certain velocity and work is done in imparting this velocity to the particles of steam. The work thus done appears as kinetic energy, or energy of motion, and its amount expressed in foot-pounds is one-half the product of the mass of the moving steam times its velocity in feet per second squared. This work is done by the steam at the expense of some of the heat energy it contains.

In a theoretically perfect and frictionless nozzle, the heat given up by the steam in British thermal units, multiplied by 778, is equivalent to the kinetic energy imparted to the moving steam. Theoretically, steam expanding in an engine cylinder does the same amount of work as the same steam expanding through the same range in a nozzle and acquiring a certain velocity. In both cases some heat is lost by conduction, radiation or internal friction, and the work done on the piston or the jet is never actually equivalent to the heat given up. The ratio of the heat actually converted into work to that which theoretically should be converted into work in a perfect engine or nozzle is the Rankine efficiency, or, better, the "efficiency ratio."

Since one horsepower is work done at the rate of 33,000 ft.-lb. per min. and one B.t.u. is equivalent to 778 ft.-lb. of work, it follows that one horsepower will be equal to 33,000 ft.-lb. divided by 778, or 42.42 B.t.u. per min., which in turn is equal to 2545 B.t.u. per hour.

If a cylinder or nozzle could be made of some material that is perfectly frictionless and nonconducting, no heat could be lost and it would all be available for work. Steam expanding in such a cylinder or nozzle is said to expand adiabatically; that is, no heat is added or taken away from the steam during expansion. However, the steam does work, and as previously stated, for the work to be done an equivalent amount of heat must be given

up. The heat given up and converted into work during adiabatic expansion is at the expense of the internal energy of the steam, and as a result, part of the steam condenses. If it were initially superheated, the superheat disappears if expansion is continued far enough, and with further expansion part of the steam condenses.

The practical engineer is interested in the amount of heat converted into work during adiabatic expansion from a certain initial condition of pressure and quality to a certain final pressure. It is possible to compute this quantity[1], but to furnish a simple and accurate means of graphically determining the amount of heat thus converted into work, the so-called total-heat-entropy diagram has been constructed. This diagram is available with the "Marks and Davis Steam Tables," and part of it is shown in Fig. 1. On the diagram the vertical scale represents total heat and the horizontal scale, entropy. Pressure lines are drawn diagonally from the lower left-hand side to the upper right-hand side, and superheat and quality lines are drawn from the upper left-hand side to the lower right-hand side. To use the diagram proceed as follows:

Use of Heat-Entropy Diagram

Suppose we start with one pound of steam at 100 lb. abs. pressure and 100 deg. superheat and let it expand adiabatically to a 28-in. vacuum, which is equivalent to 0.97, or practically 1 lb., absolute pressure. How much heat is converted into work?

Find the intersection of the 100-lb. pressure line with the 100-deg. superheat line, and read the initial total heat on the scale horizontally to the left. From the intersection follow vertically down to the 0.97-lb. pressure line, and again read the final total heat on the scale at the left. The initial heat minus the final heat is the heat converted into work per pound of steam. For the case in hand the initial heat equals 1240 B.t.u.; the final heat, 930 B.t.u., and the heat converted into work, 310 B.t.u. Since one horsepower-hour is equivalent to 2545 B.t.u., it follows that a theoretically perfect engine or nozzle working between these pressure limits would require $\frac{2545}{310} = 8.21$ lb. of steam per horsepower-hour. If by actual test it is found that the engine uses 12 lb. of steam per horsepower-hour, the efficiency ratio, or Rankine efficiency, is $8.21 \div 12 = 68.4$ per cent.

By the use of the total heat-entropy diagram, it is possible to determine with ease the steam used per horsepower per hour by a perfect engine or turbine working between any given or assumed limits within the range of the chart, and the Rankine efficiency is found by dividing this theoretical consumption by the actual consumption found by test. It is to be borne in mind that the total heat-entropy diagram is constructed for one pound of steam only, and the fact that entropy is plotted on the horizontal scale need not confuse the engineer, since it does not enter directly into any of his calculations. Two instructive articles appeared in the issues of May 29 and June 5, giving simple demonstrations of exactly what entropy is.

The engineer is next interested in finding some means by which he can determine the velocity steam should attain in expanding through a nozzle from a given initial pressure to a certain final pressure. To meet this necessity there is printed alongside of the total-heat-entropy diagram a scale of heat ranges and the corresponding theoretical velocities that should be attained. It has been found that steam in expanding through a given nozzle attains a maximum velocity at the narrow section, or throat, when the pressure against which it is expanding drops to 0.58 of the initial pressure, and that this maximum velocity cannot be increased by further decreasing the back pressure. The throat velocity, then, is determined by finding the total heat in the initial condition and from it subtracting the total heat remaining after expansion to a pressure equal to 0.58 of the initial. This difference laid off on the velocity scale will give the theoretical throat velocity. By means of a properly designed divergent outlet for the nozzle, the velocity can be further increased in proportion to the square root of the heat drop. The final theoretical velocity is determined by finding the difference between

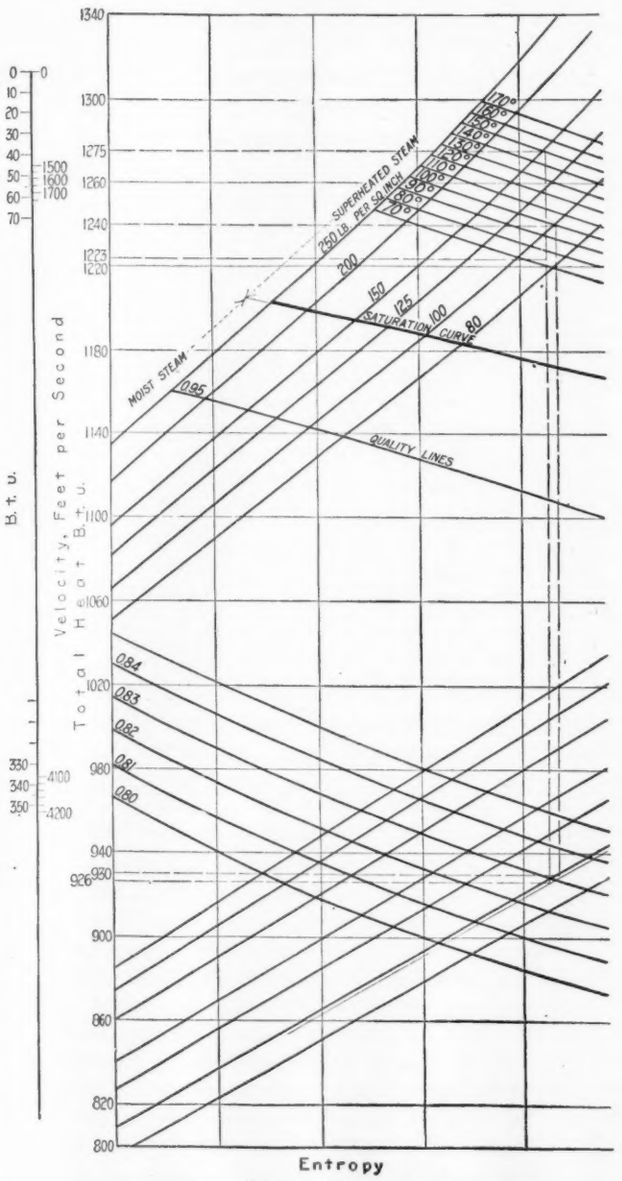


FIG. 1. TOTAL HEAT-ENTROPY DIAGRAM

the initial and final total heats and applying it to the heat-velocity scale. Evidently the quantity of steam discharged is determined by the area of the throat sec-

[1] See "Power," June 5, 1917, page 773.

tion; that is, for a given initial condition of temperature and pressure, there is a certain theoretical rate at which steam will be discharged through the throat. If it is known how much steam a turbine will require, it is only necessary to provide a sufficient number of large enough and properly designed nozzles to deliver the steam.

For instance, suppose 500 hp. must be produced with a turbine using steam at 150 lb. abs. pressure, 150 deg. superheat and a Rankine efficiency of 65 per cent. Turning to the total heat-entropy diagram, it will be found that steam in expanding adiabatically from 150 lb. abs. and 150 deg. superheat to a 28-in. vacuum gives up 1275 — 926 = 349 B.t.u. per lb. Since one horsepower-hour is equivalent to 2545 B.t.u., 500 hp.-hr. will be equivalent to 1,272,500 B.t.u. and the theoretical steam consumption of the turbine will be $\frac{1,272,500}{349} = 3646$ lb. per hour. Since the efficiency is only 65 per cent., the actual consumption becomes $\frac{3646}{0.65} = 5609$. Hence it is necessary to provide nozzles sufficient to discharge this amount of steam per hour.

Throat Velocity

The pressure in the throat of the nozzles is $0.58 \times 150 = 87$ lb. abs. In expanding adiabatically from 150 lb. abs. and 150 deg. superheat to 87 lb., 1275 — 1223 = 52 B.t.u. will be theoretically converted into kinetic energy, or energy of motion. Applying this to the heat-velocity scale, it will be found that the theoretical throat velocity is 1620 ft. per sec. Actually the velocity will be somewhat less than this owing to friction and eddy losses due to mechanical imperfections in the nozzles. The efficiency of the nozzle ranges from 90 to 95 per cent., and assuming 95 per cent., the actual velocity for the case in hand becomes 1540 ft. per sec.

Referring again to the total heat-entropy diagram, it is found that by the time the steam has expanded to the throat pressure—namely, 87 lb. abs.—it has lost 77 deg. of its superheat. The superheat remaining is only 73 deg., and from the steam tables we find that at 87 lb. pressure and 73 deg. superheat the volume per pound of steam is 5.65 cu.ft. The total volume of steam passing through the throat of the nozzle is $\frac{5614}{3600} \times 5.65 = 8.82$ cu.ft. per sec. If four nozzles are used, the volume of steam in cubic feet per second passing through each throat will be 2.205, and the area of each will be $\frac{2.205}{1540} \times 144 = 0.206$ sq.in. where 2.205 = volume, 1540 = velocity in feet per sec., 144 sq.in. = 1 sq.ft. The diameter corresponding to an area of 0.206 sq.in. is 0.512 in. After passing the throat of the nozzles, the steam continues to expand; its temperature falls further, and more heat becomes available for producing velocity. The discharge or divergent side of the nozzle must be proportioned so as to allow the steam to expand gradually and utilize all the available energy for producing velocity. The shape of the nozzle section is not material, the vital qualities being that there be no sudden or abrupt changes, and that the areas at successive points be such as will enable the given volume of steam to pass at the velocity it has acquired due to expansion. It is more desirable to have a nozzle that underexpands than one that overexpands; that is, the eddy loss due to the steam's not quite expanding in the nozzle to the final pressure is less than that caused by its expanding in the nozzle to a pressure below the final.

Returning again to the case in hand, there is a heat drop of 349 B.t.u. due to adiabatic expansion from the initial condition of 150 lb. pressure and 150 deg. superheat to a 28-in. vacuum. Referring to the heat velocity scale, 349 B.t.u. will produce a theoretical velocity of 4175 ft. per sec., and with a nozzle efficiency of 95 per cent. the actual exit velocity will be 3966 ft. per sec. From the total heat-entropy diagram it is seen that in the final condition the steam is only 83 per cent. dry. The volume of a pound of dry steam at 28 in. vacuum is 339.6 cu.ft. Hence, the volume of a pound 83 per cent. dry will be 282 cu.ft. and the volume leaving each of the four nozzles will be $\frac{1404}{8600} \times 282 = 110$ cu.ft. per sec. The area of the nozzle in cubic feet multiplied by the velocity in feet per second is the cubic feet discharged per second. Thus, if A is the exit area in square inches, V the velocity of the steam leaving the nozzle in feet per second, and Q is the volume of steam leaving the nozzle in cubic feet per second,

$$Q = \frac{AV}{144} \text{ or } A = \frac{Q}{V} \times 144$$

Hence, $A = \frac{110}{3966} \times 144 = 4$ sq.in., and the diameter of the exit, if circular, is 2.25 in. Generally, the nozzle is tapered uniformly from the throat to the exit, although the theoretical shape would be slightly curved.

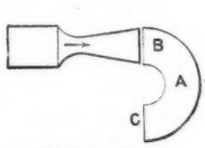


FIG.2 Impulse

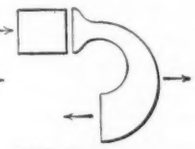


FIG.3 Reaction

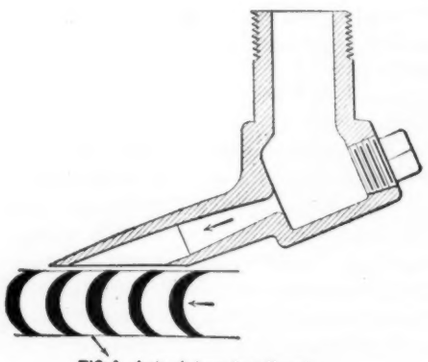


FIG.4 Actual Impulse Nozzle

The length of the nozzle is determined by empirical rules being given approximately by the formula,

$$\textit{Length in inches} = 3.9\sqrt{\textit{Area at throat in sq.in.}}$$

Having thus seen how the nozzles are designed to convert heat energy into energy of motion, or kinetic energy, the next step is a consideration of how the kinetic energy imparted to the steam is transformed into useful work. There are two fundamental methods of accomplishing this in the steam turbine, and various combinations of these fundamental methods are also used.

1. Turbines in which the steam is completely expanded in stationary nozzles and directed onto the blades of a single rotating wheel are known as pure impulse turbines.

2. Turbines in which the steam is completely expanded in nozzles on the periphery of a single rotating wheel are known as pure reaction turbines.

In the first case power is derived by virtue of the blow or impact of the rapidly moving steam on the buckets, whereas in the second case power is derived by the reaction of the mass of steam leaving the nozzle buckets at high velocity.

Fig. 2 illustrates diagrammatically one nozzle and bucket on the wheel of an impulse turbine. Steam entering the bucket A at B passes through it and is completely reversed in direction as it leaves at C. It is not practicable to construct a nozzle and bucket as shown in Fig. 2 and secure a complete reversal of flow. Instead of the nozzle being directed parallel to the plane of the wheel, it must be inclined to it, and the steam enters at an angle and leaves at an angle, as shown in Fig. 4.

Relative Speed of Steam and Wheel

If for the sake of simplicity, it is assumed that the steam enters and leaves parallel to the wheel, as in Fig. 2, it can be shown that for the most economical operation of an impulse turbine the wheel should run so that its bucket speed is just half that of the entering steam. For the nozzles just designed, from which the steam leaves at a velocity of 3966 ft. per sec., the bucket speed should then be 1983 ft. per sec. and if the wheel is 3 ft. diameter, it must make

$$\frac{1983}{3.1416 \times 3} \times 60 = 12624 \ r.p.m.$$

On the other hand, for the pure reaction turbine, a bucket and nozzle of which is illustrated in Fig. 3, it can be shown that the most desirable bucket speed is that of the leaving steam. Hence, in this case the bucket speed should be 3966 ft. per sec., and if the wheel is 3 ft. diameter, it must make 25,248 r.p.m. The objections to the pure impulse and reaction types are apparent, and while the speeds given here are somewhat greater than would actually exist in practice, owing to the assumption of complete reversal of flow and the neglect of frictional losses in the buckets in the case of the impulse type, the principles involved are well illustrated.

To design a steam turbine to operate at best economy and at moderate speeds, some means of dividing the expansion into stages must be resorted to. One way of accomplishing this is to let the expansion take place in a single stationary nozzle, as in the case of the pure impulse type just described, and direct it onto the buckets of a wheel moving at one-quarter of the velocity of the steam leaving the nozzle, instead of one-half. The steam leaving these buckets will then be capable of doing more work and can be redirected by means of stationary guide vanes onto the buckets of a second wheel moving at the same rate as the first. All the energy can thus be utilized and the speed reduced by one-half. If it is desired to reduce the speed by one-third, three rows of moving buckets must be used, etc. This is called velocity staging and is resorted to by many prominent turbine builders.

Another method of accomplishing the same result is to arrange successive nozzles and wheels so that the steam is only partly expanded in each set of nozzles, there being a sufficient number of sets to utilize all the available energy in the steam. If the wheel velocity is to be reduced by one-half, the velocity of steam leaving the nozzle must be reduced by one-half, and since the velocity is in direct proportion to the square root of the heat drop, the expansion must be divided into four pressure stages. Again, if it is desired to make the velocity one-third of that obtained in a single-stage turbine, the expansion must be divided up into nine pressure stages. This is called pressure staging, and it also is resorted to by several builders.

Pressure Staging on Reaction Turbine

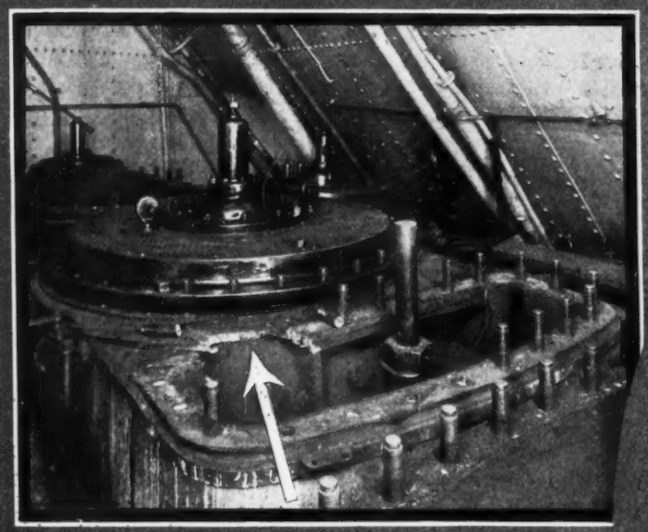
This latter method, while described for the impulse type, can be used with the reaction type as well, but the rows of moving buckets required to obtain the same final speed for the same range of expansion are more, for, as has been shown, the economical speed of the reaction turbine is twice that of the impulse turbine. Since in either case the velocity must vary as the square root of the energy drop, there must be four times the number of stages in the pressure-staged reaction turbine as in the pressure-staged impulse type, But as ordinarily built, the so-called reaction turbine is a combination of the pure impulse and pure reaction types, and there are actually two pressure stages per row of stationary and moving vanes, so instead of there being four times the number of wheels in the pressure-staged reaction turbine as in the pressure-staged impulse type, there are generally only twice as many.

Combination Turbines

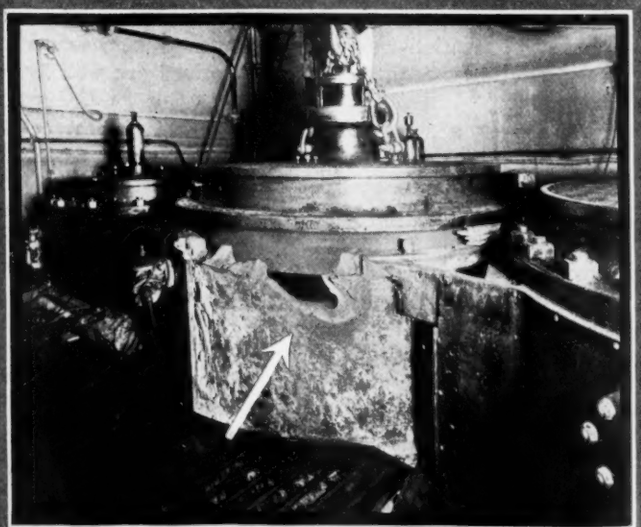
Frequently, combinations of impulse and reaction types are used in the same turbine. For instance, the first wheel may be purely impulse and the succeeding wheels reaction. It should be remembered, however, that in the case of the impulse type, the pressure on each side of the moving wheel is the same and the tendency for leakage around the ends of the blades and through the packing is a minimum. Hence, the clearances can be liberal and there is not great danger of rubbing or interference. While on the other hand, in the case of the reaction type where the expansion takes place in the moving wheel, the pressure on the entrance side is greater than that on the discharge side of the wheel, and there is a maximum tendency for leakage around the ends and through the clearance spaces. The clearances must therefore be as small as possible, and there is always danger of stripping wheels or of interference.

After velocity staging and pressure staging and combinations of both have been resorted to, it is still not possible economically to produce low enough speeds for many purposes to which it is desirable to apply the steam turbine. Reduction gears having ratios as high as 20 to 1 have been succesfully designed and machined, by means of which a pure impulse wheel running at 10,000 r.p.m. can drive a centrifugal pump at 500 r.p.m. The propellers of many large ships are also turbine-driven by means of reduction gears, so that a successful gear-cutting department has become indispensable to the turbine builder.

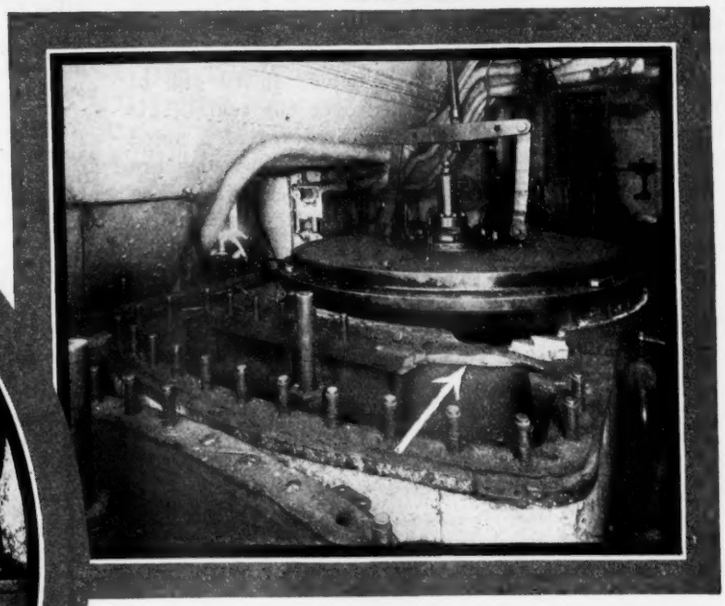
"Schrecklichkeit" did this to G



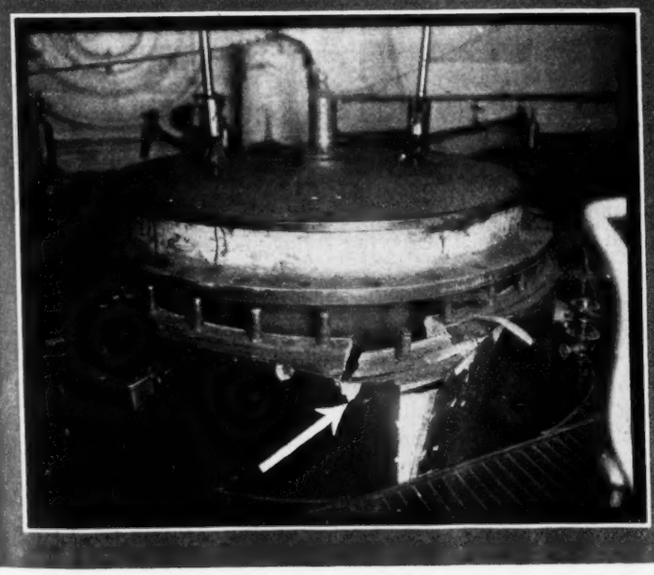
This is the first authentic publication anywhere, by permission of the United States Government, of the way in which German ships in American ports were damaged prior to the declaration of war.

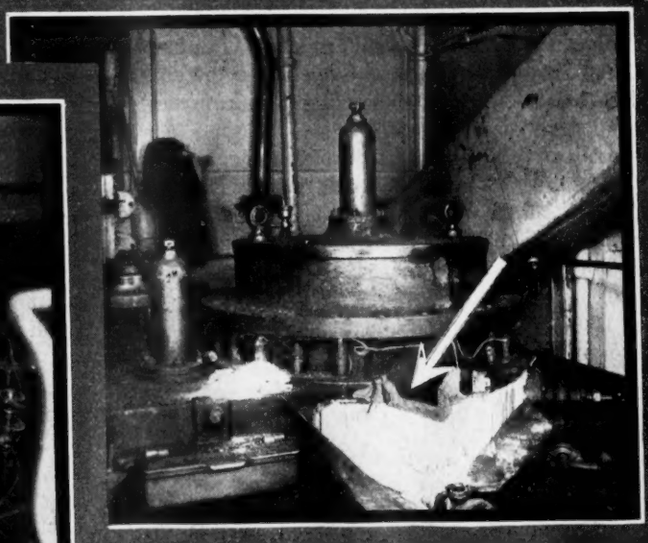


to German Ships before their Seizure



Cylinders were loaded with scrap iron and then steam turned on, smashing heads and flanges. Rags and carpets stuffed into working parts helped out the hurried but effective destruction.





Well! Well! Fyrox

When salt can be bought at the grocery store at three pounds for a nickel, why pay a dollar a pound? This question is asked because we have recently received from various sources several circulars issued by the Fyrox Co. of Pennsylvania and of New York, setting forth the merits of Fyrox (over 77 per cent. salt), a preparation that is claimed to make two tons of coal do the work of three, when dissolved in 10 gal. of water and the solution sprinkled over the coal. This compound, says a circular, is the discovery of a noted French-Canadian chemist. About sixteen reasons are given why Fyrox should be used as a fuel saver. The reproduced advertisement from a Philadelphia newspaper is a sample of what is printed to catch the gullible.

In order to be able to tell our readers just what Fyrox is, we purchased a 1-lb. box for $1 at the New York office, 141 Broadway, and sent a sample to a reputable chemist for analysis. Here is what it is:

Free moisture	0.63
Combined moisture	7.50
Calcium sulphate	1.75
Magnesia	0.81
Zinc	0.11
Iron	0.78
Sodium chloride (salt)	77.36
Sodium oxychloride	10.36
Manganese	trace

The base of the compound is principally common salt, as has been the case of other so-called fuel savers. Salt produces a highly colored flame when sprinkled on a hot fire, but it does not increase the heat value of the fuel.

One of the circulars contained testimonials. Among others was the following: "New York Central, Port Morris—More evaporation and power, less ash." The chief engineer of the Port Morris power plant disclaimed, over the telephone, making such a statement. He said that a party was around the plant with some kind of compound at the time stokers were going in, but that he had never used any of it.

Another reads: "Tartar Chemical Co., Brooklyn—Cost generating 100 hp. hour reduced from 43c. to 33.6c." The manager of the works, in a telephone conversation, stated that he had never authorized any such statement and that the compound was not used at the plant.

"Very satisfactory, less ash" is given for the Elks Club, New York City. Over the telephone the chief engineer stated that he had never used any of the preparation.

In order to make sure that the New York engineers were "all wrong," we wrote to the Taylor Electric Co., of Toronto, Can., the testimonial of which read, "Saved 50 per cent." The letter came back marked, "No such firm in Toronto." The Y. M. C. A. of Montreal, Can., had a testimonial as follows: "Decreased cost of generating 100 hp. per hour from $1.03 to 78c." Here is what the secretary wrote in reply to our letter:

> Your inquiry re Fyrox just received. Our engineer tells me that he has never used a compound by this name for sprinkling over coal.
>
> About two years ago a salesman tried to sell us a composition called Caloroxide. He made some tests which looked very favorable for Caloroxide. However, we did not buy, our engineer being of the opinion that a good fireman was worth more than all such compounds put together. Fyrox may be another name for Caloroxide.
>
> So far as I know, we have never given the firm any testimonial.
>
> (Signed) W. H. HENDERSON,
> Secretary.

Getting nearer home, a representative of Fyrox called at the engine room of the McGraw-Hill Publishing Co., Inc., the home of *Power*, a short time ago to introduce the compound. He was desirous of running a test. F. L. Johnson, chief engineer, readily gave his permission, but the representative of Fyrox has, up to the present, failed to return.

In a letter to Mr. Johnson an offer was made to send sufficient material to make his own test. Mr. Johnson replied to the New York company as follows:

> Gentlemen—I am burning about twelve tons of coal per day and would like to try Fyrox. If you will send me a free trial sample, I will use it at my earliest convenience and report the result.
>
> (Signed) F. L. JOHNSON,
> Chief Engineer.

President Wilson
Says
In his last proclamation that

Every Patriotic Citizen should exercise greatest economy in all manner of living! No greater waste occurs in any source of outlay than uncalled for waste in coal consumption in homes as well as in factories. The cost of coal will steadily increase during the period of the war

You Can Save Coal
By Using
FYROX

A practical and expedient method of getting 25 to 40% more out of your coal, making coal last longer and burn better. Long used in Canada, France and New York City. Before you order your coal for next winter let us mail you reports of local users of Fyrox. You can get along with fully one-third less coal than heretofore.

Full particulars free on request.

Fyrox Company of Penna.
807 Chestnut St.

REPRODUCED NEWSPAPER ADVERTISEMENT

The sample has failed to materialize and the test was not made. We wonder why? Again we ask, What is the use of buying salt at a dollar a pound to increase the cost of each ton of coal 50c., when practically the same results can be obtained for a cent and a half if one feels that a fuel-saving compound must be used?

A device has been developed at the Johns Hopkins University by means of which water can be elevated by attaching a spring-loaded relief valve to the cylinder of an internal-combustion engine. Immediately after each explosion this valve discharges a certain portion of the hot gases through a nozzle similar to that of an ejector, and water is drawn from a reservoir and is discharged through a pipe and elevated to a height of about 75 ft. Enough gas of explosion is left in the cylinder at each working stroke to cause the engine to continue to operate in addition to pumping water.

Editorials

How About Other Coal Consumers?

WHEN Secretary of the Navy Daniels recently resorted to arbitrary military authority and proceeded to commandeer steel, coal and oil for the Government, telling the producers that their asking prices were exorbitant and that prices would be adjusted later on a basis of actual cost plus a reasonable profit, this price to be established by the President when the Federal Trade Commission had determined a fair rate, it was a step in the right direction. The present fuel need of the navy is 1,750,000 tons of coal and 50,000,000 barrels of oil. The bituminous coal producers were asking the Government $2.95 per ton at the mines, which, with the freight charges, made the cost at Hampton Roads $4.35 per ton, an increase of more than $1.50 over last year's price. These prices are approximately $3 less than those quoted to the public at that time. Secretary Daniels has offered $2.33 per ton as a preliminary payment, leaving the balance to be fixed upon later. For oil that last year sold at Port Arthur at 89c. per barrel the producers are now asking $1.58 to $1.86. They, too, have been ordered to furnish the oil and leave the price to be determined later, when the actual cost is known.

Having the power, this is what the Navy and War Departments should do. But it must have caused the millions of other consumers of coal and oil to ask the questions: How about us? Are we to be the victims of exorbitant prices? How about the central stations throughout this country which are endeavoring to render the public an efficient and adequate electric service? Are they to be forced to pay the coal operators profits, which the War and Navy Departments say is exorbitant for the Government? Is an unjust price to the Government a fair price to the public and public utilities? If $4.35 per ton is an unfair price for the Government, is $6 to $12 a fair price to the public? If the service rendered by a public utility and the rates charged for it are regulated by law, in justice to this utility is it not entitled to protection by the Government against an unjust burden?

The announcement made last week that the bituminous-coal operators had agreed to make a reduction in their prices ranging from $1 to $5 per ton, with a further reduction of 50c. to the Government, has somewhat relieved this situation. However, this agreement does not affect the cost of anthracite, and for the present no general change of prices in this product is contemplated. If the experience of the European nations is a criterion, then the coal problem is a long way from being solved, and will not be outside of Government control.

After the beginning of hostilities in Europe, most of the nations found their coal supply in serious danger and it became necessary to take far-reaching governmental action to safeguard it. It was pointed out in the "Federal Trade Commission Report on Bituminous Coal Trade," published in our June 19 issue, that "in England the government took complete control of the coal mines after less radical methods of regulation failed. The French government has drawn up a scheme for dividing France into three coal zones in order to equalize distribution, and the government becomes the vendor. On May 2, 1917, the Russian provisional government took over all the coal mines of that country with a view to controlling coal distribution and prices. Soon after the outbreak of the war Germany took measures to centralize the whole industry of the empire under government control. The Italian government imports all the coal brought into the country and acts as a clearing house for its distribution."

In a second report on the coal situation, an abstract of which is published in this issue, the commission states further, "The pooling of coal in the hands of a Government agency would still be ineffective, either as to distribution or as to the promotion of a maximum of production, unless similar control extended over all means of transportation, both rail and water; and to meet this the pooling of railroads and boat lines is clearly indicated. Our allies and Germany require that the railroads not already government-owned be operated as a unit and on government account, and the allies have officially stated that one reason for being certain of victory was that transportation had been reorganized and perfected."

Taking these facts into consideration, there seems to be no logical reasons why, since we are facing the same condition in this country that Europe faced in reference to the coal supply and transportation facilities, the Government should not only take over and regulate the distribution of the coal supply from the mouth of the mines to the ultimate consumer, but should also establish the prices to be paid for coal by the different classes of consumers. This, the Federal Trade Commission's report clearly indicates, can only be successfully done when the Government has control over all lines of transportation.

German Perfidy

POWER is gratified to be able to present to its readers the first published photographs of the destruction wrought on the machinery of the German vessels in American ports. The illustrations on pages 54 and 55 of this issue, taken on the German ships "Bulgaria" and "Rhein and Neckar" at Baltimore, give some indication of the damage done and the difficulties presented to the Shipping Board in getting the vessels ready for service. Cylinders, reciprocating parts, bearings—in fact, all vital elements—were rendered useless and similar measures were taken in the boiler room. Destruction was thorough and in some cases so bad as to make repair almost hopeless.

Ruthless and wanton as the destruction may appear to our readers, it is to be regarded as a war measure in line with German conduct of the past three years. Abusing the courtesy and restraint of our liberal Government is nothing to "kultured" minds that have perpetrated such terrible atrocities on the high seas and back of the lines in Belgium and northern France. It was of no moment that up to the minute war was declared these ships, which had sought the hospitality and refuge of our harbors, were free to leave at any time. Crews were allowed to remain on board, and little restraint was placed on their actions.

Object lessons such as these and the proposed Mexican plot have gone a long way in bringing home to Americans the nature of their present foe. They may well serve to inspire prompt and just retribution.

Declining Influence of Lighting Loads

FOR many years, in fact since the beginning of the electric-lighting industry, the peak load of the winter season has been the controlling factor in central-station investment. Advocates of various rate systems have based countless arguments favoring the stand-by charge and high maximum rate for lighting supply upon the capacity carried throughout the year in order that the demands of the extreme lighting peak might be met. In support of such schedules many load curves have been exhibited showing what had become almost a standard relation between the peak and the demands of the daylight hours, the relative heights of the curve varying mainly with the locality and the season of the year.

With the development of the motor load the shape of even the yearly peak-day curve has changed more than many engineers appreciate. On page 60 are printed two twenty-four-hour load curves taken from progressive central stations in the same state on the days of maximum output during a yearly period. The shape of these curves is remarkable in comparison with the type of curve still regarded as orthodox by many.

In one plant the maximum load of 6100 kilowatts exceeded the sustained day load by but eleven per cent. In the other, the maximum of 10,900 kilowatts was barely nine or ten per cent. above the day load. Now in these plants the growth of motor business has been rapid and the day loads are very well maintained from month to month. The yearly load factors were twenty-five and six-tenths per cent. and forty-two and five-tenths per cent. and on the peak days the load factors were forty-two and fifty-six and five-tenths per cent. Observe that the peaks occurred in June and February rather than in December, in the year taken, and note also the large volume of power output sold compared with the lighting sales. With the earlier types of load curves there easily might have been a difference of fifty or sixty per cent. between the lighting peak and the day load; but in these plants, which are typical modern stations, the motor service is responsible for the great bulk of the output sold.

These curves and the tabular data accompanying, indicate that the time is at hand when the dominance of the lighting load as a factor in station investment must yield in many cases to the requirements of capacity for power production. It naturally follows that ultimately there will be less difference between lighting and power rates, so far as those rates are affected by plant investment, than was economically justified when the maximum lighting peak was the expression of the central-station manager's greatest anxiety in the year's run.

American Red Cross War Council Needs

PRESIDENT WILSON has created a Red Cross War Council of seven members to administer the American National Red Cross during the war, with Henry P. Davidson, of J. P. Morgan & Co., as chairman. More than a billion dollars has been raised to relieve suffering and restore to health and strength the sick and wounded who are and will be fighting for us on the battlefields of Europe. The obligation of raising this vast amount of money for the relief work should have rested on every man, woman and even the children of America. Although the appeal for a billion dollars met with a hearty response and was more than subscribed, there will be a request for more as the weeks go on. Here will be a chance for those who missed the first opportunity.

Buying a Liberty Bond, for which you will get your money back plus interest, does not contribute to these relief funds. It must come from the people as a wholehearted gift. Your "bit" may be for your own son.

Hundreds of American doctors and nurses are now at the front. Some twelve thousand American engineers will rebuild the railroads of France. About twenty-five thousand American volunteers are now fighting with the Allied armies, and several thousand American regulars will soon be beside them, fighting under "Old Glory." More than this, America will soon have the full strength of our National Guard and an army of five hundred thousand, and later there will be an army of one million and a navy of a hundred and fifty thousand.

Preparations by the Red Cross must be made for their needs in the shape of hospital stores and equipment, as well as supplies of every kind before they are wanted—not afterward. Ambulances will be required to care not only for our own but for the Allied wounded. The homeless of France are suffering for the barest necessities of life. They need clothing, agricultural instruments, horses and cows, tools, household utensils and many other articles.

All such requirements must be supplied by the American Red Cross, if at all. That is why a billion dollars was necessary. That is why those who cannot fight should contribute freely to the most stupendous and appealing calls for money in the history of the world.

The opinion seems prevalent, based probably on conditions a few years back, that the large gas engine is rapidly on the decline and will soon be a thing of the past. Therefore many will be surprised to learn that there are now in course of construction a large number of these units for at least four of the biggest steel plants in the country. Some of these engines will be of more than four thousand horsepower and will be employed both for blowing and for driving electric generators. It appears then that the large gas engine business was merely lying dormant, awaiting the impetus to the steel industry which has been supplied by the conditions arising out of the war.

Correspondence

Testing Boiler-Feed Water

J. R. Belknap's article on page 808 of the June 12 issue, concerning tube troubles with vertical water-tube boilers, is interesting, and it is noted that he considers that the failures are due either to high alkalinity from the water-softener system or to scale preventives. In regard to the former, it is known that the solid contents of feed waters vary from day to day and to operate a water softener for best results, frequent analyses must be made and treatment must be adapted to conditions. In some plants daily analysis is made on which to base the treatment. If such methods are not used, the value of the water softener may be nil. But beyond this, most water softeners using the "cold" treatment methods result in soda in the boiler and foaming follows, and a certain concentration exists in combination with a high rate of evaporation. In a Western railroad service, a pure high-flash mineral oil was used as a blanket over the surface of the water to prevent foaming, and good results were obtained. It has also been proved that when tannic acid, usually in the form of extract of hemlock, is added, the tendency toward priming or foaming is greatly reduced and often completely eliminated.

Circulation Responsible for Tube Trouble

In addition, however, the matter of circulation may have a bearing on tube trouble. With vertical water tubes of the two-pass design, trouble may result in the front pass, due to steam collecting in the tubes in the second pass, and cause reversal of the circulation. If steam is generated in the second-pass tubes, then by having steam collected in a tube until the circulation, normally downward, reverses and the contents are ejected upward, it follows that this would cause surging in the lower drum, especially with water heavily charged with soda. Since the circulation in the first pass is very strong, it is possible that the surging may momentarily cut off the water to one or more tubes at the lower end of the first pass, in which event, of course, low water might result, which would account for the tube failing by overheating and resultant rupture.

Method of Improving Circulation

To overcome this the Cahall vertical boiler was provided with outside "down current" pipes, and the Cook vertical boiler, with a central large downflow flue about 18 in. in diameter.

Equally good results may be obtained, however, by providing short projecting tubes and driving these in the lower ends of the tubes in the first pass, having the short tubes project 10 or 12 in. below the lower tube sheet. Old tubes can be cut up and one end heated and drawn down thin for insertion, or thin tubes of No. 16 galvanized iron can easily be made and used. Such tubes would of course remove trouble due to surging in the lower drum since the inserted tubes would have the lower ends in solid water, and these tubes could be taken out and replaced whenever the turbine cleaner is used.

In the foregoing it is assumed the tube failures are in the first pass, since failure rarely occurs in the second pass, probably on account of the lower temperatures. The matter of boiler water becoming "wild" when soda is used is an interesting subject that does not seem to have received the attention it deserves. Mr. Belknap's letter should bring out the experience of others for the benefit of all. DANNY HOGAN.

New York City.

Iron Fittings Caused Voltage Drop

In your issue of Apr. 24, appears an article on "The Installation of Motors—IV," Fig. 11 in which shows a method of running the power line through a partition; the same arrangement being shown herewith in Fig. 1. I wish to call your attention to this method, which is a very poor arrangement electrically, but is done by many electricians and passed by some inspectors.

When running a single wire on an alternating-current line through an iron or steel pipe, and especially a power line, considerable induction is caused in the circuit, producing a drop in potential, low power factor,

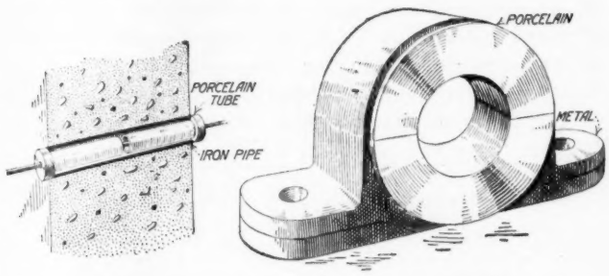


FIG. 1. BUSHING HOLE IN THICK WALL

FIG. 2. PORCELAIN-BUSHED CABLE CLAMP

and a wattage loss, which is consumed in heating the pipe.

I know of an instance where power cables were run on cable clamps which caused a 15 to 20 per cent. voltage drop in 200 ft. The clamps were porcelain-bushed iron rings, similar to that shown in Fig. 2, designed for direct-current work, and the alternating current caused them to become quite hot. This trouble was found only after considerable testing and finally by a man touching a clamp. However, where the current is low the loss is small, but the method of running the wires is nevertheless wrong. W. F. SHEDINGER.

Philadelphia, Penn.

[It is a well-known fact that all metal fittings near an alternating-current circuit will be heated owing to eddy currents induced in them by the alternating field, especially where only one leg of the circuit is present.

Nevertheless, the construction shown in Fig. 1 is correct according to the National Board of Fire Underwriters' Code. However, it would be interesting to have further discussion on the foregoing points by readers of *Power* and to know what their experiences have been with similar conditions.—Editor.]

Central-Station Load Curves Changing

For many years the peak load of the winter season has been the controlling factor in plant investment in the average central station. Rate schedules have been built upon the ratio of this peak to the normal demand upon the installation, and much emphasis has been laid upon the amount of idle capacity that it has been necessary to carry through the greater part of the year to meet the load conditions of winter. Numerous companies have met their peak demand in Christmas week, and from fall to summer the lighting load of the early evening hours has until recently dominated the chart of station output.

	Plant A	Plant B
Rated kw. capacity of station	20,000	11,785
Connected motor load in kw	14,069	7,905
Number of motors on lines	2,745	3,455
Kw.-hr. sold in year, power	22,823,008	9,958,574
Average revenue per kw.-hr. power, c.	1.85	1.44
Total revenue from power sales	$423,084	$143,800
Kw.-hr. sold in year, lighting	8,032,060	1,732,504
Average revenue per kw.-hr. lighting, c.	6.64	8.6
Total revenue from lighting in year	$533,466	$148,762
Maximum lighting rate per kw.-hr., c.	9	11
Average load in kw., peak day	6,150	2,564
Maximum load in kw., peak day	10,900	6,100
Load factor on peak day, per cent	56.5	42
Average load throughout year, kw.	4,650	1,555
Yearly load factor, per cent	42.5	25.5

With the development of the motor load, a remarkable change has come to pass in the shape of station-load curves. Figs. 1 and 2 illustrate two typical load curves of the most modern type, each being taken on the day of maximum output during the entire year. The two plants serve manufacturing cities of about 150,000 and 60,000 population respectively. It is noteworthy that in Fig. 1 the maximum output of the year occurred on a day in June, while in Fig. 2 the peak output was in February. The dominating influence of the motor load, with its sharp but temporary reduction during the noon hour, is apparent in both cities. It is apparent also that the lighting load, even in the case of the station with the winter peak, added but 10 per cent. or thereabouts to the maximum demand upon the plant at the heaviest hour. Typical data from the two plants are tabulated in the table.

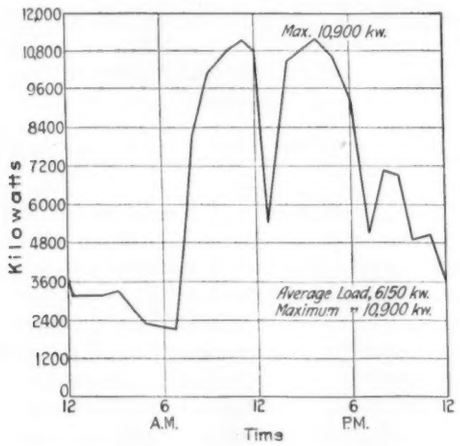


FIG. 1. LOAD CURVE FOR CITY OF 150,000 POPULATION

It is evident from these curves and figures that the central station has a long way to go before it can escape the burden of carrying a very substantial amount of idle capacity in its investment through a large part of the year. The lighting peak, however, is today over-

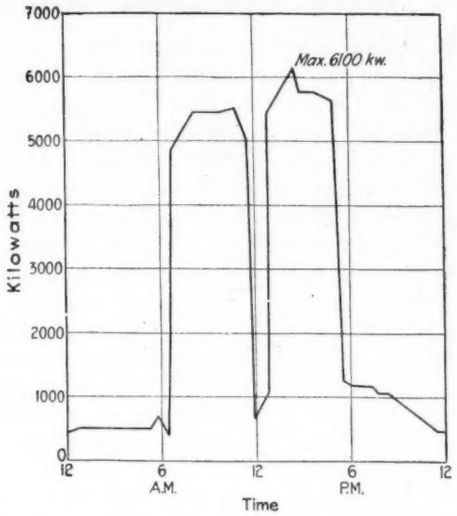


FIG. 2. LOAD CURVE FOR CITY OF 60,000 POPULATION

rated in many installations as the most serious factor in investment for rate making, compared with the growing importance of the station capacity needed to supply the motor load. It would be going too far to claim that lighting rates are therefore too high, in the face of the present cost of plant operation in war time, but if industrial demands upon central stations continue, it is safe to assume that the gap between lighting and power rates will ultimately be considerably diminished.

H. S. KNOWLTON.

Cambridge, Mass.

Higher Steam Pressures

The question of higher steam pressures seems to warrant and demand continued discussion, judging by the interest shown as indicated by articles in the technical press.

In his article, "Buffalo's Notable Power Plant," in the Feb. 13 issue, Mr. Bromley states: "After one has looked about, one begins to appreciate that excepting the 10 per cent. or 12 per cent. gain that may be had by increasing the heat range by going to higher pressures or superheat, there is no other source, as far as can be seen at present, for bettering the economy of the steam plant."

It seems, however, that the possibilities of increasing the efficiency of a steam plant by increase in the temperature range are not confined alone to the pressure and superheat, as there are possibilities still remaining at the vacuum end. It may even be that the gain in efficiency physically possible at the lower end of the range is also more nearly attainable commercially than is the gain to be had at the upper end of the range.

Mr. Bromley says later that it is not likely that pressures of 500 or 600 lb. will be used commercially

for some time to come, and that new plants will probably stop their increase from 200 lb., at 300 to 350 lb. for a long pause before going higher.

A discussion of the gain to be expected from the use of higher vacuum as against very high pressures and superheats may therefore be of interest. As it is admitted that higher pressures and superheats will cost more money, not only for the construction of the boiler, but for the piping and high pressure end of the turbine casing, we may eliminate from the present discussion consideration of the added cost of the condenser and auxiliaries.

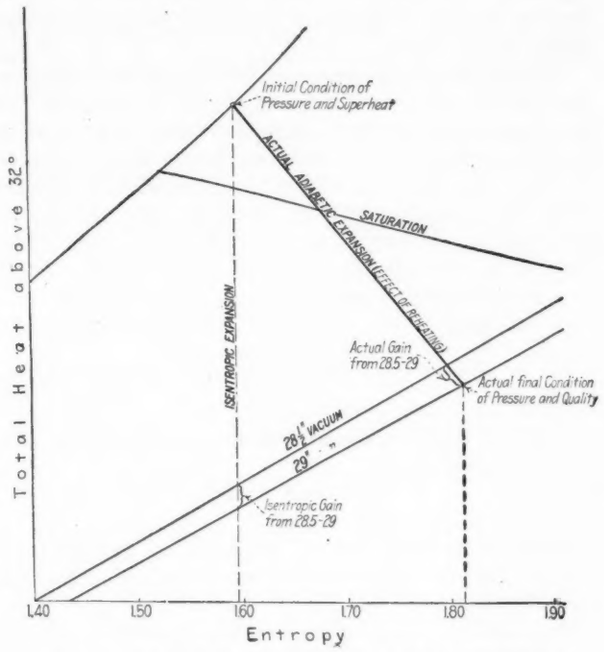


FIG. 1. PART OF MOLLIER DIAGRAM, SHOWING TENDENCIES ONLY

The general trend with large units is to design the turbine for 29 in. vacuum and the condenser for 29 in. vacuum under conditions of average yearly water temperature. The full-load vacuum obtained are somewhat over 29 in. in the winter with very cool water, about 29 in. in the spring and fall with water at about 50 deg. F., and from 28 to 28½ in. in summer with water at 70 to 75 deg. F. Good operating results show that the difference between the vacuum temperature and the incoming water temperature is 25 to 35 deg., depending on the season. Thus under operating conditions a vacuum of 28½ in. is obtained with water at 60 to 65 deg. It is evident that there still remains a considerable margin for an increase in vacuum of, say, a half-inch under these conditions, and an equal lowering of the exhaust temperature and increase in heat range under other water conditions.

Assuming that an increase of heat range corresponding to an increase in vacuum from 28½ to 29 is contemplated, a comparison with a contemplated increase in pressure from 350 to 600 lb. can now be made. The accompanying table gives the heat available by isentropic expansion to 28½ in. and 29 in. vacuum with initial steam pressures at 350 and 600 lb., and the total steam temperature of 700 deg. With 350 lb. pressure and 700 deg. total temperature, an increase in vacuum of 28½ to 29 in. increases the heat available from 450 to 470 B.t.u., whereas if the vacuum is maintained the same at 28½ in. and the pressure increased to 600 lb with the total temperature remaining the same, the heat available is increased from 450 to 477½ B.t.u.

29-IN. VACUUM

Pressure	Superheat	Total Temp.	Vacuum	Initial Heat	Final Heat (Isentropic Expansion)	Diff. = Heat Available in Perfect Engine
600	213	700	29	1,353	858	495
350	268	700	29	1,360	890	470
			28½-IN. VACUUM			
600	213	700	28½	1,353	876.5	477.5
350	268	700	28½	1,360	910	450

The gain by increasing the vacuum at 350 lb. is 20 B.t.u. per pound; that by increasing the pressure at 28½ in. of vacuum 27.5 B.t.u. per pound. This is the gain with isentropic expansion in a perfect engine, and we must next consider the actual adiabatic gain and also the additional energy convertible into work.

The actual gain in work obtained by the increase in vacuum is greater than would be hastily inferred from the figures given, for two reasons: In the first place, the actual gain in heat energy is more than 20 B.t.u., shown by the subtraction of the two figures for heat available by isentropic expansion. Expansion in a turbine is modified by the reheating of steam as it passes from one stage to another, so that the final expansion takes place at a considerably higher quality than that determined by drawing an isentropic (vertical) line on the Mollier diagram. Thus if there were no reheating with 350 lb. pressure and 700 deg. temperature and 29 in. vacuum, the quality at exhaust would be 80.4 per cent., whereas actually with the same expansion but 75 per cent. efficiency of conversion of heat energy into work, the quality is 88½ per cent. Similarly for expansion from 350 lb. pressure and 700 deg. superheat and 29 in. vacuum, the actual quality is 92 deg.

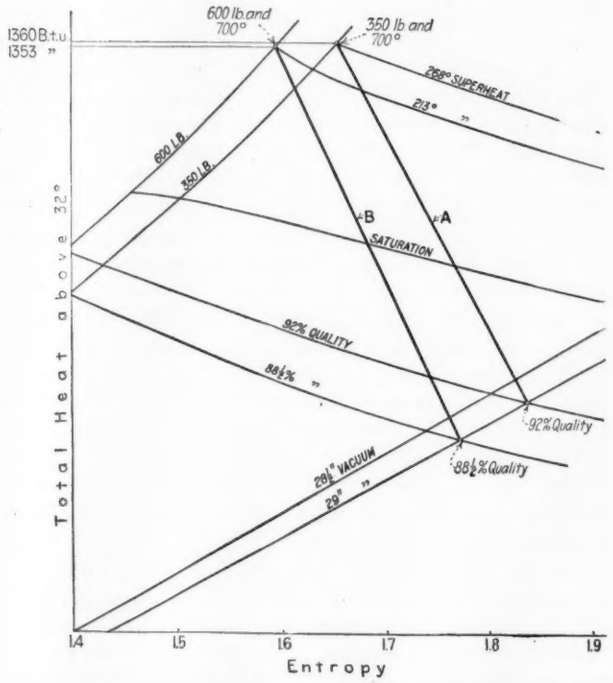


FIG. 2. SHOWING RELATIVE B.T.U. GAIN IN EXPANDING TO LOW VACUUMS

Now if we refer to a Mollier diagram, it will be found that, as shown in Fig. 1, the lines for constant vacuum diverge as we move toward conditions of higher quality and higher entropy (to the right). In other words, the heat drop from 28½ to 29 in. vacuum is greater at about 90 per cent. quality than it is farther to the left at 80 per cent. quality. This increase is appreciable, increasing the heat available from the 20 B.t.u. difference given to about 22 B.t.u. This is a 10-deg. increase, which would be expected, since the mixture expanding is 90 per cent. steam and 10 per cent. water instead of 80 per cent. and 20 per cent., or roughly contains 10 per cent. more steam. The quality and entropy at exhaust are higher, with the lower pressure and higher superheat than with the high pressure and lower superheat, the final temperature being 700 deg. in both cases. Thus in Fig. 2 the expansion from 350 lb. and 700 deg. would be similar to *A*, and from 600 lb. and 700 deg., similar to *B*, there being a difference of 3 or 4 per cent. more steam expanding in the last stages in the latter case.

Eighty Per Cent. Efficiency in Last Stages

Now the 22 B.t.u. per pound additional energy available is converted into kinetic energy in the nozzles of the last stage or stages of the turbine and thereafter converted into usable electrical energy. The efficiency of conversion is very high under the conditions prevailing at the last wheels of the turbine, owing to the relatively small skin friction, due in turn to the small surface rubbed by the steam compared to the volume flowing, and also due to the small windage loss at low steam density. It is stated that the efficiency of conversion in this part of the turbine runs as high as 80 per cent. and higher. Taking 80 per cent., the net B.t.u. of energy converted into work is 80 per cent. $\times$ 22 = 17.6, which is equal to 17.6 $\div$ 3600 additional kilowatts per pound of steam expanded to the higher vacuum. Assuming 75 per cent. efficiency of the turbine as a whole, we may calculate that there is 0.052 kw. additional obtained for each kilowatt produced at 28½ in. vacuum and that the steam rate per kilowatt is reduced from 10.65 lb. to 10.12 lb., or a saving of 0.53 lb., or about 5 per cent.

Now turning to the upper end of the heat range, suppose that instead of increasing the vacuum from 28½ to 29, the pressure of 350 lb. at 700 deg. total temperature has been increased to 600 lb. and 700 deg. total temperature. The increased energy available is 27½ B.t.u., and the amount of this energy that is actually turned into usable work at the switchboard depends on the efficiency of conversion. The efficiency of a high-pressure turbine using steam at 150 to 200 lb. is generally supposed to be around 60 per cent., and it is variously stated that with very high pressures, such as 600 lb., the efficiency would drop to 50 or 40 per cent. Assuming 60 per cent. the net gain in work is 60 per cent. $\times$ 27½ = 16½ B.t.u. Following through the same calculations as before, the gain in steam consumption is about 0.49 lb., or about 5 per cent. gain. The gain in steam economy is approximately the same as with the increase in vacuum without increase in pressure, but this does not necessarily mean the same gain, in both cases, in total plant economy. The two important losses to be considered are the heat wasted to the discharge circulating water and up the stack.

The total heat in a pound of steam at 350 lb. pressure and 700 deg. total temperature is 1360 B.t.u., and the heat per pound turned into work with 29 in. vacuum is just about 360 B.t.u. (assuming 10 lb. even steam consumption for simplicity of calculations), leaving 1000 B.t.u. discharged into the condenser, of which 47 B.t.u. is retrieved, assuming the condensate temperature as 79 deg. This leaves a net loss to the condensing water of 953 B.t.u.

With the higher pressure of 600 lb. and total temperature of 700 deg., the heat per pound of steam is 1353 B.t.u., and with the heat going into work the same, the heat discharged to the condenser is 993 B.t.u., of which 60 B.t.u. are retrieved with 92-deg. condensate temperature corresponding 28½ in. vacuum, leaving 933 net B.t.u. per lb. discharged to the condensing water. Thus for 350 lb. and 700 deg. we have

Initial heat	— work heat	— retrieved heat
(1360)	(360)	(79 — 32)
	= wasted heat	
	(953)	

and for 600 lb. and 700 deg.,

Initial heat	— work heat	— retrieved heat
(1353)	(360)	(92 — 32)
	= wasted heat	
	(933)	

There is a difference of 20 B.t.u. in favor of the higher pressure and lower vacuum, or 200 B.t.u. per kilowatt produced.

Now turning to the other source of heat loss, namely, that up the stack, we find that to produce the steam at 600 lb. pressure as against 350 lb. pressure, the boiler surface is 55 deg. hotter and therefore the uptake gases are 55 deg. hotter. With 14,000 B.t.u. coal and 80 per cent. boiler-plant efficiency, the ratio of steam to coal is 8.65, and with 20 lb. of gas per pound of coal, there are 23 lb. of flue gas per kilowatt. The higher flue-gas temperature represents a heat loss of 23 $\times$ 0.24 $\times$ 55 = 305 B.t.u. This is somewhat more than the difference in heat loss to the discharge condensing water when the higher vacuum was used.

It would seem that there is just as much, if not more, to be gained by increase in vacuum as by increase in pressure, and that the future will witness constant increase at both ends of the heat range.

New York City. Paul A. Bancel.

[In nearly all of the discussion on what is the most economical vacuum to carry in a turbine, the authorities participating have contended that except under unusually favorable conditions it costs more to maintain over 29 in. than such low pressures are worth.—Editor.]

Plaintiff while engaged in performing his duties as engineer operating a crane and while driving a nut on the crosshead pin, the nut being so worn that a hammer and chisel were used to turn it, was injured through the engine suddenly starting, whereby he missed a stroke directed at the chisel, and the force of the blow caused injury to his wrist. He sued his employer on the ground that the accident was directly due to the employer's negligence in failing to previously repair the leaky condition of the engine valve, and the Alabama Supreme Court has affirmed judgment in his favor. (Warner vs. United States Cast Iron, Pipe and Foundry Co., 73 Southern Reporter, 936).

Inquiries of General Interest

Required Diameter of Pump Plunger—Knowing the number of gallons to be pumped per minute, what is the formula for finding the required diameter of a pump plunger?

R. G. A.

For 100 ft. of piston speed, the actual displacement would be 100 × 12 × area of piston in square inches ÷ 231 = gal. per min., or

$$\frac{1200 \times 0.7854d^2}{231} = \text{gal. per min.}$$

from which

$$\text{Diameter of piston in inches} = \sqrt{\frac{\text{Gal. per min.}}{4.08}}$$

but for practical purposes the formula for 100 ft. of piston speed may be

$$\text{Diameter of piston in inches} = \sqrt{\frac{\text{Gal. per min.}}{4}}$$

and for any piston speed,

$$\text{Diameter of piston in inches} = \sqrt{\frac{\text{Gal. per min.} \times 25}{\text{Actual piston speed}}}$$

Different Methods of Hand-Firing Bituminous Coal—What are the different methods of hand-firing bituminous coal?

J. M. A.

There are three general methods of firing, known as the coking method, the alternate method and the spreading method. In the coking method the fresh coal is placed just inside of the furnace door and allowed to remain there until the heat from the furnace drives the hydrocarbons out of the coal, after which the fuel, in the form of coke, may be pushed back into the hotter portions of the fire to complete the combustion. In the alternate method fresh coal is fired in a thin layer, first on one side of the grate and then on the other. Combustion of the volatile matter and burning of the carbon occur continuously, and it is unnecessary to alter the air supply to correspond with different stages of the combustion. In the spreading method very little coal is fired at a time, but it is fired often and each charge is fired evenly over the entire fire in a thin layer, or the method is modified by firing the coal in patches covering only portions of the grate.

Pressure Indicated by Ordinary Steam Gage—Does a boiler steam gage indicate the actual pressure within the boiler, and if not, why are not boiler-pressure gages made to show the actual or absolute pressure? L. N.

Steam gages ordinarily are marked to indicate pressure above the pressure of the atmosphere. The absolute pressure within the boiler is the pressure indicated by the gage plus the pressure of the atmosphere. The exterior of the boiler is subjected to atmospheric pressure, and the effective pressure that tends to rupture the boiler is the difference between the absolute pressure and the pressure of the atmosphere, and therefore this same difference of pressure commonly called "boiler pressure" or "gage pressure," is the pressure that is indicated by an ordinary steam-pressure gage.

In the ordinary forms of pressure gages the pressure to be measured acts on one side of the walls of a tube or diaphragm and is opposed by atmospheric pressure on the other side. As the pressure of the atmosphere is variable, markings of the gage in absolute pressures could be correct for only the particular atmospheric conditions for which the dial was laid off, and for measuring absolute pressures it is more practicable to take the sum of ordinary gage readings and atmospheric pressure obtained with a barometer.

Boiler Capacity Required for Heating Water—Neglecting losses of heat by radiation, what capacity of boiler horsepower would be required for heating 8000 gal. of water per hour from 50 deg. F. to 200 deg. F. in 30 min. by means of pipe coils supplied with dry saturated steam at 40 lb. gage if the condensate, as formed, is relieved by traps and returned to the boilers at 100 deg. F.? J. A. A.

To heat 8000 gal., or 8000 × 8.33 = 66,640 lb., of water from 50 deg. F. to 200 deg. F. would require 66,640 × (200 — 50) = 9,996,000 B.t.u. Each pound of steam at 40 lb. gage, or 55 lb. absolute, when condensed in the coils, would liberate the latent heat of evaporation of the steam, or 919 B.t.u., and for heating the water would require service of steam at the rate of $\frac{9{,}996{,}000}{919} \times \frac{60}{30} = 21{,}754$ lb. of steam per hour.

The total heat of a pound of steam at the pressure of 55 lb. absolute is 1175.4 B.t.u. above 32 deg. F., and for conversion of each pound of feed water at 100 deg. F. into steam at that pressure would require 1175.4 — (100 — 32) = 1107.4 B.t.u.; hence the serice of steam to the coils would require transfer of heat by the boiler at the rate of 21,754 × 1107.4 = 24,090,380 B.t.u. per hour. One boiler horsepower is equivalent to the evaporation of 34.5 lb. of water per hour from a feed-water temperature of 212 deg. F. into steam at the same temperature, and as the latent heat of evaporation per pound of water at 212 deg. F. is 970.4 B.t.u., a boiler horsepower is equal to the transfer of 34.5 × 970.4 = 33,479 B.t.u. per hour. Therefore, neglecting losses of heat by radiation, as stated, the boiler capacity required would be 24,090,380 ÷ 33,479 = 719.5 boiler horsepower.

Horsepower of Boiler—What would be the horsepower of a horizontal return-tubular boiler, 72 in. diameter, with seventy 4-in. tubes? J. J. P.

The term "horsepower" is applied to a boiler with reference to rate of evaporative capacity and also with reference to size. The commonly accepted boiler horsepower unit of capacity is a transfer of heat equivalent to the evaporation of 34.5 lb. of water per hour from and at 212 deg. F. The number of boiler horsepower capacity developed depends on the rate of combustion of fuel, the cleanness of the heating surfaces and other actual conditions affecting the rate of evaporation. Rating of a boiler's horsepower size applies only to the extent of its heating surface, regardless of whether the boiler is capable of developing a greater or less evaporative capacity. Unless otherwise stipulated, boiler size usually is rated in accordance with "builder's rating" of 10 sq.ft. of heating surface per horsepower, and for horizontal return-tubular boilers the heating surface generally is assumed to consist of two-thirds of the surface of the shell and, based upon the exterior diameter of the tubes, the area of all the tubes, plus two-thirds of the area of both tube sheets, less twice the cross-sectional area of all tubes.

The heating surface and horsepower of a horizontal return-tubular boiler 72 in. diameter by 18 ft. long, containing seventy 4-in. tubes, estimated according to builder's rating would be as follows:

Heating surface of shell = $\frac{2}{3}$ of 72 × 3.1416 × 18 × 12 = 32,572 sq. in.

Heating surface of tubes = 70 × (4 × 3.1416) × (18 × 12) = 190,004 sq. in.

Heating surface of tube sheets = $\frac{2}{3}$ of (72 × 72 × 0.7854 × 2) — (4 × 4 × 0.7854 × 70 × 2) = 3669 sq. in.

Total heating surface 226,245 sq. in. = 1571.1 sq. ft.

Allowing 10 sq.ft. per horsepower, the size of the boiler per builder's rating would be $\frac{1571.1}{10} = 157.1$ horsepower.

Report of Federal Trade Commission on the Coal Situation

In the June 19 issue, was published a report of the Federal Trade Commission on the bituminous coal trade. A further report was issued by this commission on June 20, covering both the bituminous and anthracite coal situation. The following is an abstract of the later report.

While conducting its various inquires, the commission has exerted all the powers which have been conferred upon it by Congress in any effort to soften hard conditions.

It is fair to say that, as a general rule, the various parties in the anthracite coal industry have evidenced their desire to coöperate with the commission, and while by reason of the war emergency the commission has at times pressed its activities in the public interest to the limit of the authority granted to it by Congress, there has been no serious disposition to question whether or not it has tended to exceed its powers.

In the anthracite industry the commission has elaborated a system for tracing the coal from the point of its production on through all intermediate hands, and finally to the point of consumption. Weekly reports are required from producers and jobbers, wherever needful, with the result that as regards domestic sizes, high-premium coal has largely been eliminated from the market and speculation and excessive profits have been cut out in the wholesale trade of these sizes.

Production of Anthracite Coal

During the first two months of the coal year of 1917 (April and May) there was an increase in the production of anthracite of 2,433,000 tons as compared with the first two months of the coal year of 1916. This is an increase of 24 per cent. and should have been transferred into a distinctly favorable condition of the market.

However, faulty rail and water transportation and conditions in the bituminous industry and in the production, control, distribution and use of coke have been such that much of the gains which should have been secured by the efforts of the commission, aided by the intelligence and willing coöperation of a great majority of the interests engaged in the production and distribution of anthracite, has been lost.

The close supervision of anthracite thus fails as a remedy so long as butuminous runs wild, and the commission's plan as to anthracite cannot be extended over the bituminous industry because of the wide field and the great variation in conditions. The commission is nevertheless continuing its efforts, and will continue them vigorously, pending the solution of the whole fuel problem by Congress.

The production of bituminous coal for the first two months of the coal year of 1917 (April and May) showed a large increase, but not nearly so large as the increase in industrial consumption and not nearly so large as the possible and economical output of mines already open and in partial operation.

Production of Bituminous Coal

The present production of bituminous coal, the country over, is about 40 per cent, short of the posible maximum, and this limitation is solely to be charged, as to primary cause, to faulty rail transportation. The present demand for coal is unprecedented, but the mines now open are capable of filling this demand if adequate car supply is furnished.

We find that mine labor is being disorganized by reason of irregular employment and enforced idleness, and that in some fields bituminous mines are working only three or four days a week, and that willing labor and willing operators are standing idle half the time. In other fields where there is now a more nearly adequate car supply, the irregularity of car supply for months past has so disorganized and disturbed labor that these mines are not nearly at full capacity of production.

The commission believes that there are enough coal cars in the country, but that there are not enough coal cars delivered to the mines, and that, an inadequate supply having been delivered to the mines and loaded, these cars are not moved to the point of consumption with the greatest of expedition, nor are they promptly discharged upon arrival at their destination.

The commission has much testimony of widespread abuse in the use of coal cars, by speculators, for the storage of coal for speculative purposes, and that the practice of reconsignment is wasteful, and a cause of delay and market manipulation. The commission finds that coal is not sent to the point of consumption by the most direct route, and that coal cars have been used for transportation of many other kinds of products.

The commission believes that the coal industry is paralyzing the industries of the country, and that the coal industry itself is paralyzed by the failure of transportation. The coal problem cannot be worked out so long as the railroads are permitted to divide and allot traffic; to lay embargoes without regard to their immediate effect upon industry or upon the systematic distribution of coal; to give priority to the movement of high-freight commodities and to use the device of "long haul."

Coal Industry Paralyzing Other Industries

The situation in New England is made acute because of the disruption and disorganization of barge transportation. The cost of the water haul from New York to Boston increased from 50c. a ton to as high as $3 a ton. From Newport News bituminous coal is paying $3.50 to $4 per net ton instead of the normal 70 to 90c. to New England.

The serious aspect as to the country at large is the immediate and intolerable hardship laid upon industry and transferred in large part to the public with increased prices, which will fall upon domestic consumers next winter.

The supply is inadequate because it is unnecessarily limited by transportation conditions. The price of coal to railroads and other large consumers has generally increased from 100 to 150 per cent., while prices to small consumers have often increased as much as 200 to 400 per cent., and in some cases even more. The increased fuel cost is secondary manufacturing processes and in commerce can be and is passed on to the consuming public in the form of higher prices. The prices are not only raised to meet present unheard-of fuel prices, but in contracts for future delivery a factor of safety is put in to cover future expected speculative increases in fuel prices.

The municipal public-service corporations, on the other hand, generally have their rates fixed by their franchises or by law, and fuel is the largest factor in their cost of operation. Already applications are being made to municipalities and state utilities commissions asking for increased traction fares and for higher rates for electric current and for gas. If these increases are granted, it means that another item of this tremendous cost will be passed on to the public. If these increases are not granted, then many municipal-service corporations whose present rates are based on a fair rate in relation to their investment will be crushed under the unjust burden.

Pooling All Coal and Coke Production

It would seem that steady employment, fair compensation for labor and capital, equitable distribution and stable prices could be secured by pooling all coal and coke production in the hands of the Government.

If the producers at each mine were paid the full cost of production with allowance for depletion, maintenance, upkeep and all the usual items, and to this were added a fixed and uniform net profit per ton, with due regard to quality, the coal thus produced at widely varying costs, if pooled, could be sold through the Government at an average and uniform price, quality considered, which would be entirely tolerable to the consuming public, and a price much lower than could be fixed if an effort were made to fix a uniform price to the producers.

Such a method would require careful supervision as to economical operation, but this task and the expense involved in performing it would be very small in proportion to the net saving gain to the nation. As a matter of fact, many large contracts are being made on a basis of cost of production plus an agreeable profit.

The pooling of coal in the hands of a Government agency would still be ineffective either as to distribution or as to

the promotion of a maximum of production unless similar control was extended over all means of transportations, both rail and water, and to meet this, the pooling of railroads and boat lines is clearly indicated. The railroads of the country, if operated as a unit and on Government account, could be used to transport coal and other products by the most direct route to their point of destination, and the efficiency of the roads themselves, and of existing rolling stock and of the motive power, would thus be vastly increased.

All receipts from all rail and water transportation agencies being held in the hands of the Government and all expenses of operation paid from the common fund, each individual company should be paid a just compensation, which might be measured by the average annual net profit and expenditures for maintenance and betterment for the five years period prior to the war.

The operation both of the mines and of the transportation agencies could be carried on by the present employers and officials, and after the war they could be returned unimpaired to private operations. The rolling stock of railroads, operated as a unit, could be mobilized so as to care for the shifting season demands.

In view of the foregoing the commission recommends:

First, that the production and distribution of coal and coke be conducted through a pool in the hands of a Government agency; that the producers of various grades of fuel be paid their full cost of production plus a uniform profit per ton (with due allowance for quality of product and efficiency of service); and,

Second, that the transportation agencies of the United States, both rail and water, be similarly pooled and operated on Government account, under the direction of the President, and that all such means of transportation be operated as a unit, the owning corporations being paid a just and fair compensation which would cover normal net profit, upkeep and betterments.

A. I. E. E. Special Meeting

The annual convention of the American Institute of Electrical Engineers, which was to have been held at Hot Springs, Va., June 26 to 29, was postponed on account of many conditions arising from the war, and in its place a special two-day convention was held in New York City on Wednesday and Thursday, June 27 and 28, at which were presented and discussed the papers that were to have been presented at the annual convention.

The special meeting opened at 10:30 Wednesday morning in the Engineering Societies Building, 29 West 39th St., President H. W. Buck, after a few brief remarks, called upon the authors to present their papers. The subject for this session was "High Tension Cables"; four papers were presented. John L. Harper presented the first, on "Problems in Operation and Maintenance of Underground Cables." The author points out that owing to the scarcity and high cost of transmission materials it is necessary that transmission capacities of electric underground cables be increased to a maximum. The causes of failures in cables of good workmanship and design are due to joint troubles, mechanical injury to the lead sheath and overheating. The conclusion is drawn that overheating is the most important consideration. It is recommended that the conduit system be flooded with water to assist in removing the heat from lead-covered cables and thus approach practically the conditions of submarine cables. In the discussion it was pointed out that there were other important factors, such as the insulating compound used in making the joints, and the effects of high-voltage tests, to be considered in preventing underground cable failures. Many of the members did not take very kindly to Mr. Harper's idea of flooding the conduit system.

The second paper, "The Fundamentals of High-Tension Cable Joints," by D. W. Roper, was presented by the author and outlined specifications intended to apply to joints of cables operating at about 20,000 volts and upward, but that in general may be found of importance on cables operating above 10,000 volts.

"The influence of Dielectric Losses on the Ratings of High-Tension Underground Cables," by A. F. Bang and H. C. Louis, was the third paper on the program and was presented in abstract by Mr. Bang. This paper discusses a series of tests made to determine the dielectric losses of 13,000-volt cables at different temperatures, to compare cables of various types and those of different manufacturers with one another in the foregoing respect and, if essential differences are found, to investigate the possible causes of the difference, such as difference of compound used for impregnating the paper, percentage of moisture in the cable, thickness of insulation, etc.

"Insulation Characteristic of High-Voltage Cables," by W. S. Clark and G. B. Shanklin, the last paper on the morning program, was presented in abstract by Mr. Shanklin. In this paper the authors discuss in detail the insulation characteristic of different types of single- and three-conductor cables determined largely by dielectric-energy-loss measurements.

After the presentation of the papers Mr. Buck introduced Capt. Gustave Paul Cappart, of the French Army, an electrical engineer and a member of the French Scientific Commission to this country, who was heartily cheered by all those present. Captain Cappart conveyed the greetings of the French electrical engineers to the members of the American Institute of Electrical Engineers, and remarked: "We used to say time is money; now we say time is blood. It is now for you to make the world safe for democracy by victory." The session was then given over to the discussion of the papers previously read, in which a goodly number took part.

High-Tension Insulator Session

The Wednesday afternoon session was called to order by Vice President L. T. Robinson. This meeting began with a continuation of the discussion of the paper read at the morning session. After this discussion, the subject of the afternoon session, "High-Tension Insulators," was taken up. Three papers were presented. The first, "The Insulator Situation," by W. D. Peaslee, in the absence of the author, was presented by H. R. Woodrow. This paper reviews the insulator situation at the present time and the specifications laid down by some operating engineers as to the requirements of insulators for reliable service. The apparent cause of the rapid deterioration of some insulators, even when stored are considered and microphotographs showing the structure of the porcelain are given.

"Expansion Effects as a Cause of Deterioration in Suspension-Type Insulators," by J. A. Brundige, was read by the author. In this paper consideration is given to porosity and mechanical cracking through expansion effects, as the two general causes put forward for the rapid deterioration of suspension-type insulators, and data are presented in support of the latter. The author also discusses some of the operating problems that have to do with insulator failures.

The third paper of the afternoon session, "Present Practice in the Design and Manufacture of High-Tension Insulators," by A. O. Austin, was presented in abstract by the author, who by the use of a number of lantern slides gave a very interesting talk, which treated of the problem in the design and manufacture of porcelain insulators.

After the reading of the paper, a large number of members took part in the discussion, in which the opinion was expressed that although there are some features of the insulator problem today that tend to give it a pessimistic outlook, nevertheless there are other indications that in the near future important improvements will be made in the porcelain insulator.

President's Annual Address

The Wednesday evening session was called to order by President H. W. Buck, who then delivered his annual address, taking for his subject, "The Position of the Engineer in Modern Times." Mr. Buck pointed out that, although engineering has been one of the most important factors in the development of our civilization, nevertheless the engineer has had a difficult struggle to begin to attain the recognition due him. However, the particular training that the engineer acquires in the pursuit of his profession particularly fits him to fill every position in our political

and economical affairs, and in the future he is destined to occupy more and more positions of public trust.

Mr. Buck then introduced E. W. Rice, Jr., president-elect of the Institute for the coming year. Mr. Rice after expressing his appreciation of the trust placed in him by electing him for the high office of president of the American Institute of Electrical Engineers, addressed the meeting on the subject, "Modern Warfare a Question of Engineering." He said in substance that although it is important that we have an army at the front, the most effective work can be done in the shop and office at home by bending forth every effort toward supplying the army at the front with all the modern appliances of warfare to make it most efficient, and not to wait for the miracle that will never appear. He expressed his belief that the submarine problem will be solved by the combined efforts of the engineers and scientists, that we should build ships and the best kind of ships and that all shipping should be used to the best advantage; that it is not so much a question of the number of ships as it is a case of keeping them in use, which means that our docks must be equipped by the most modern apparatus for loading and unloading the vessels so as to keep them in service.

C. O. Mailloux then announced that recruiting for a corps of electrical engineers and electrical workers, to go to France, would soon begin, to build up the electrical systems in that country. This announcement was in advance of the official notice, which is expected to be made in the near future. This corps will be similar to the body of railway engineers that was recently organized in this country to build up the transportations system in France.

The evening session was closed by the presentation of the reports of the various technical committees.

Thursday morning at 10:30 the session on the "Use of Electricity in Mines" was called to order by Vice President C. A. Adams. Two papers were presented at this session—one on "Forms of Electric Power Best Suited for the Various Loads Encountered in the Operation of Bituminous Coal Mines," by R. L. Kingsland, and "Test of a Large Mine Hoist," by R. S. Sage. Mr. Kingsland in his paper gives consideration to the best forms of power to use in coal mines for drilling, cutting, hauling, lighting, pumping and ventilation. The question of synchronous converters versus motor-generator sets and the location of substation and generating plants is also discussed. It is recommended that lead-covered steel-armored cables running direct from the surface through special bore holes into the mine are best suited for concentrated power of 100 hp. and over. These cables may be used for voltages up to 11,000 volts.

Mr. Sage in his paper describes an 1800-hp. Ilgner-Ward-Leonard hoist installed at the mine of the Elm Orlu Mining Co., Butte, Mont. The complete data are given on two different tests made on this equipment, one conducted to analyze a typical day's run and the other to determine the efficiency while hoisting. These data are compared with those calculated when the hoist was designed.

At the afternoon session, which was the final, President H. W. Buck occupied the chair. Two papers were read. The first, on "Economical Combinations of Water-Power and Steam Plants and a Convenient Method of Solution," by H. St. Clair Putnam, described a method for determining the economic limits in steam and water-power developments. This paper will be abstracted in a later issue.

The second paper, "Cooling of Oil-Immersed Transformer Windings After Shutdown," by V. M. Montsinger, was presented by the author. This paper was to have been given at the Schenectady meeting in April, which was canceled. It discusses the three general methods recognized by the A. I. E. E. Standardization Rules for determining the temperature of electrical apparatus. The usual theoretical formula for calculating the cooling of a body is not in a convenient form for practical use, and when it is necessary to make calculations, more accurate results can be obtained by a partly empirical method determined by the author and given in the paper. A total of 218 members registered.

Power Plant Practice

The reader will remember that last fall it was announced that the Wentworth Institute, Boston, Mass., had added a course in steam and electrical power-plant practice to its curriculum. This course is somewhat different from most similar courses in that power-plant practice forms the main study subject. It is one of the first, if not the first, class of its kind to be conducted by such an institute. The accompanying photograph shows the class which has completed its first term of the work.

CLASS IN STEAM-ELECTRIC POWER-PLANT ENGINEERING, WENTWORTH INSTITUTE, BOSTON

Council of National Defense and Advisory Commission

There is a somewhat general lack of information regarding the organization known as the Council of National Defense and its Advisory Commission and the various boards, sections and committees of which it consists. The chart herewith gives a graphic and comprehensive outline of the organization as it stands at present, and for the first time the work already accomplished by the Council is made public, as given in a report to the Secretary of War by the Director of the Council, as follows:

The mobilization of the 262,000 miles of railroads for the Government's defense; the close-knit organization of the telephone and telegraph companies; the settlement of the recent threatened strikes.

The very general acceptance by labor and capital of the suggestion of the Council that existing labor standards should not be changed until the need for such action had been determined by the Council with the steadying influence on industry growing out of such action; the procurement of 45,000,000 lb. of copper for the uses of the Army and Navy at a saving to the Government of approximately $10,000,000; similar accomplishments as to steel, zinc, etc.

The completion of the inventory, for military purposes, of 27,000 American manufacturing plants; the appointment over the country of committees of business men to assist the quartermasters' department of the Army in the purchase of supplies; the coördination of purchases through the agency of the General Munitions Board.

The creation, under the medical section, of a General Medical Board; the selection of thousands of doctors specifically qualified for membership in the medical reserve corps, and the standardization of surgical instruments and supplies.

The creation of the Aircraft Production Board, which is setting out to make 3500 airplanes and to train 6000 aviators this year.

Definite results have been obtained by the Committee on Coal Production in the mining and shipment of coal, both in the civilian and Federal interests.

The initiation of a movement to coördinate the activities of the states for the national defense, by the conference of states held recently in Washington at the call of the Council.

The organization of a railroad committee to send to Russia and the enlistment of reserve engineer regiments to aid in rehabilitating the roalroads of France.

Complete Details Cannot Properly Be Given

Such a summary however excludes many of the details of the council's accomplishments. The duties and functions of the Council as defined by the act of Congress which created it are, among other things, the "coördination of industries and resources for the national security and welfare," and the "creation of relations which will render possible in the time of need the immediate concentration and utilization of the resources of the nation."

In performing its functions the Council is further charged with the following duties:

1. To supervise and direct investigation, and make recommendations to the President and the heads of executive departments as to: (a) The location of railroads with reference to the frontier of the United States, so as to render possible expeditious concentration of troops and supplies to points of defense; (b) the coördination of military, industrial and commercial purposes in the location of extensive highways and branch lines of railroads; (c) the utilization of waterways; (d) the mobilization of military and naval resources for defense; (e) the increase of domestic production of articles and materials essential to the support of armies and of the people during the interruption of foreign commerce; (f) the development of seagoing transportation; (g) data as to amounts, location, method and means of production and availability of military supplies; (h) the giving of information to producers and manufacturers as to the class of supplies needed by the military and other services of the Government, the requirements relating thereto, and the creation of relations which will render possible in time of need the immediate concentration and utilization of the resources of the nation.

2. To report to the President and heads of executive departments upon special inquiries or subjects.

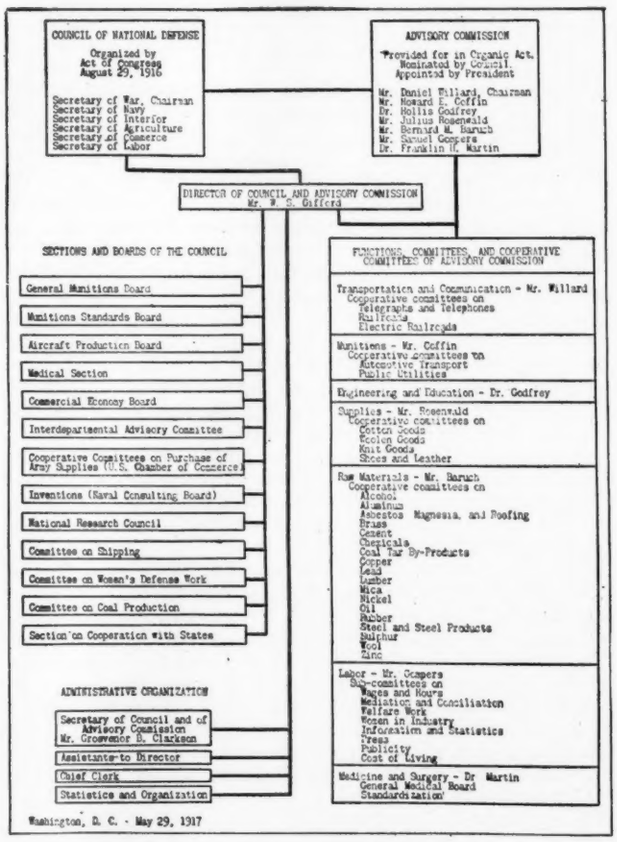
3. To submit an annual report to Congress, through the President, giving as full a statement of the activities of the Council and the agencies subordinate to it as is consistent with the public interest, including an itemized account of the expenditures made by the Council or authorized by it, in as full detail as the public interest will permit, providing, however, that when deemed proper the President may authorize, in amounts stipulated by him, unvouchered expenditures and report the gross so authorized not itemized.

The members of the Advisory Commission and the particular duties in their charge are:

Daniel Willard, chairman, president of the Baltimore & Ohio R.R., transportation and communication.

Howard E. Coffin, vice president of the Hudson Motor Co., munitions, manufacturing, including standardization and industrial relations.

Julius Rosenwald, president of Sears, Roebuck & Co., supplies, including clothing.



PERSONNEL, FUNCTIONS AND ORGANIZATION OF THE COUNCIL OF NATIONAL DEFENSE AND ADVISORY COMMISSION

Bernard M. Baruch, financier; raw materials, minerals and metals.

Dr. Hollis Godfrey, president of the Drexel Institute, engineering and education.

Samuel Gompers, president of the American Federation of Labor, labor, including conservation of health and welfare of workers.

Dr. Franklin Martin, secretary general of the American College of Surgeons, medicine, surgery and sanitation.

The Director of the Council and Advisory Commission is Walter S. Gifford, and Grosvenor B. Clarkson is the secretary.

The work of the Council is largely carried on through the assistance of civilians who serve without pay. Their services have been obtained in the full realization that the conduct of modern war requires not only fighting men but the nonpartisan specialists of every industry and science, and coördinated industries.

In the service of the Council and Advisory Commission, with the labors of both bodies touching about every angle of the nation's life, there are but eighty paid employees. Such a task can be carried on with so small a salary roll only by the volunteer service of civilians as referred to. Of these there are more than one hundred men highly trained, drawn from the fields of every industry and science, giving their entire time to the Council and Commission without compensation, and they themselves pay their living expenses in Washington. In addition there are several hundred more men of the same type giving freely a large part of their time to the work, not only in Washington, but throughout the country and the Council and Advisory Commission are enabled to carry on their labors at so low a cost only through the ungrudging aid of these volunteer, nonpaid workers.

W. S. GIFFORD,
Director of the Council of National Defense
and of the Advisory Commission.

New England States Convention, N. A. S. E.

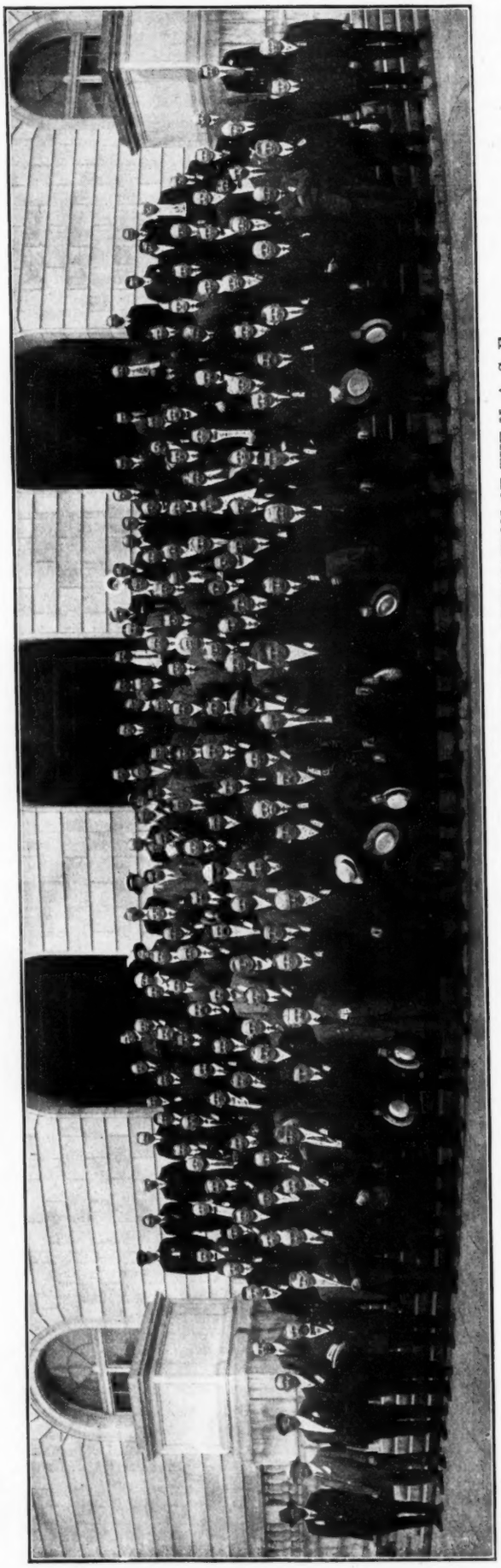
The annual convention of the New England States Association of the National Association of Stationary Engineers was held in Portland, Me., June 27 to 30, with headquarters at the Falmouth Hotel. The main hall of the City Hall Auditorium was decorated and arranged for the use of the supplymen. There were 75 booths, displaying various power-plant and engine-room supplies and equipment. The exhibits were up to the usual standard.

The attendance of delegates was fully up to the standard. The business sessions of the engineers were held on the second floor of the auditorium. Several important subjects were discussed conducive to the uplift of the organization. Many of the delegates spoke of the higher efficiency that would be required of the engineer in the future and the great responsibility that rested upon him for the welfare of the country after the war, when competition would be most keen, and urged that they take zealous advantage of the educational features of the association. The records show that there has been an increase of over five hundred in the membership of the N. A. S. E. during the last fiscal year in the New England States Association.

Under the supervision of the New England Association of Commercial Engineers the exhibition was officially opened at 8 o'clock on Wednesday evening, Fremont S. Eggleston, Jr., presiding. Wilford G. Chapman, mayor of Portland, cordially welcomed the visitors and hoped that their stay would be a pleasant one. Mr. Eggleston thanked the Mayor on behalf of the delegates and guests. H. T. Hooper, president of the Chamber of Commerce, told of the beauties of Portland and hoped that the guests would be afforded the time to visit a few of the many pleasant places of interest. Major James W. H. Myrick, treasurer of the N. E. A. C. E., fittingly responded, and assured the Mayor that the conduct of the visitors would in every way merit a future visit. Andrew Waite, chairman of the local committee of the N. A. S. E., thanked the Mayor and the president of the Chamber of Commerce for their help in making the convention a success. Claude D. Allen, past president of the N. E. A. C. E., spoke of the handsome arrangement of the exhibit hall and commended the earnest work of Andrew Waite. The ceremonies closed with the singing of "The Star Spangled Banner."

On Thursday evening there was an organ recital by Will C. Macfarlane, who has an international reputation. Among other selections Mr. Macfarlane played his "Fantasia," in which a storm is vividly depicted. The organ is on the stage of the auditorium and is claimed to be one of the largest and best in the world, being a gift to Portland by Cyrus H. K. Curtis, the Philadelphia publisher.

After the concert there was an educational meeting, at which papers were read by E. H. Kearney, past national president of the N. A. S. E., on "The Coöperation of the Operating and Commercial Engineer"; "The Practical Operation of the CO_2 Recorder," by C. H. Andrews, and "The Venturi Meter in the Power Plant," by C. G. Richardson.



DELEGATES AND SUPPLYMEN OF THE NEW ENGLAND STATES ASSOCIATION OF THE N. A. S. E.

The opening exercises of the N. A. S. E. took place on Friday morning. Chairman Andrew Waite, after a short address, introduced Mayor Chapin, who was followed by John F. Quinn, president of the New England States Association; H. T. Hooper, president of the Chamber of Commerce; Walter H. Damon, past national president; Fremont S. Eggleston, Jr., president of the N. E. A. C. E.; W. H. Brown, president of Meriden Association; and William J. Reynolds, past national president. "America" closed the ceremonies.

On Friday evening there was a smoker at Pythian Temple. The talent included Billy Murray and Joe McKenna, of Jenkins Bros.; Bert Self, of the Peerless Rubber Manufacturing Co.; James C. Donnelly, of Lowell No. 17; and Jack Armour, of *Power*. Frank Martin was the master of ceremonies.

On Saturday morning at 8 o'clock the delegates enjoyed an auto ride through the city. At 10 o'clock the delegates boarded the steamer "Metia" for a sail on Casco Bay, landing at Long Island, where an old-fashioned shore dinner was served. A baseball game between the engineers and supplymen was won by the former, the score being 7 to 5.

At the Friday afternoon session of the delegates the sum of $50 was voted to the Red Cross of America. The following state officers were elected: Joseph Eccleston, president, New Bedford; Andrew Waite, vice president, Portland; James H. Henderson, secretary, Boston; Walter H. Damon, treasurer, Springfield; E. L. Bassett, conductor, Bridgeport; Albert Keene, doorkeeper, Pawtucket. The officers were installed by William J. Reynolds, past national president.

The final meeting of the New England Association of Commercial Engineers was held on Friday afternoon. A resolution drafted by William Drouett that a telegram be sent to President Wilson commending his actions along commercial lines and approving of his appeal to hold conventions during the war was unanimously adopted. The election of officers resulted as follows: John A. Morehouse, president; George W. Denyven, vice president; James E. Morgan, secretary; James W. H. Myrick, treasurer; Fremont S. Eggleston, Jr., Seth Lee and Sandford C. Smith, directors.

At the meeting of the Connecticut State Association on Thursday the following officers were elected: William H. Brown, president; O. A. Thomas, vice president; A. Anderson, secretary-treasurer; James Tobin, conductor; David A. Wilcox, doorkeeper.

Fremont S. Eggleston, Jr., retiring president of the N. E. A. C. E., was presented a handsome Masonic charm. John Quinn, retiring president of the N. E. S. A., received a gold watch. Charles Olsen, of Jenkins Bros., was given a sterling silver cigarette case, the gift of the delegates from Bridgeport and New Haven.

Bridgeport, Conn., was selected for the next meeting.

DELEGATES AND SUPPLYMEN OF THE NEW ENGLAND STATES ASSOCIATION OF THE N. A. S. E.

Personals

William Sticht, formerly with the Singer Manufacturing Co., Elizabethport, N. J., is now mechanical engineer with the American Lead Pencil Co., Hoboken, N. J.

James G. White, president of J. G. White & Co., Inc., has been elected second vice president of the Merchants' Association of New York for the ensuing year.

H. W. Hand, formerly vice president and general manager of the Wm. Cramp & Sons Ship & Engine Building Co., Philadelphia, has been elected president of the company.

Gordon M. Campbell, formerly manufacturing engineer with the General Electric Co., West Lynn, Mass., is now works manager of the Kerr Turbine Co., Wellsville, N. Y.

D. H. Thompson has been elected president and treasurer of the Terry Steam Turbine Co., Hartford, Conn., filling the vacancy caused by the late president, James Terry.

Walter Cary, who has been associated with the Westinghouse Lamp Co. for the past 13 years, has been elected a vice president of the Westinghouse Electric and Manufacturing Co.

Gen. George H. Harries, president of the Louisville Gas and Electric Co., and vice president of H. M. Byllesby & Co., has volunteered for service in the Federal Army, of which he is a retired major-general.

James G. Rollow has resigned as combustion engineer of the Southern California Edison Co., Long Beach, Calif., to accept a similar position with the E. I. du Pont de Nemours & Co., at Wilmington, Del.

C. Edwin Clarke, formerly master mechanic of the Cambria Steel Co., Johnstown, Penn., is now chief engineer of the Wilmington Steel Co., Wilmington, Del.

Louis J. Hirt, formerly vice president of the Pearson Engineering Corporation of New York, has been appointed consulting engineer for the United Gas and Electric Engineering Corporation, and will supervise the construction and engineering work of the subsidiary companies.

H. D. Shute, whose election as vice president of the Westinghouse Electric and Manufacturing Co. was recently announced, will have executive charge of the company's commercial organization, both domestic and export, succeeding Vice President L. A. Osborne, whose headquarters have been transferred to New York.

Samuel Lindsey Nicholson, who has been sales manager of the Westinghouse Electric and Manufacturing Co. since 1909, has been promoted to the position of assistant to vice president, with headquarters at East Pittsburgh. Mr. Nicholson is unusually well known throughout the electrical profession because his varied activities have brought him in contact with its numerous branches. He is an executive of unquestioned ability and is well qualified for the new work. Beginning with the Belmont Iron Works in 1887 Mr. Nicholson had a varied experience, becoming associated eventually with the Westinghouse company.

Engineering Affairs

The Cleveland Engineering Society has issued in magazine form, under the title of "The Conquerors," a series of articles on the work of the engineer, so as to give the public a better idea of the nature and importance of the service rendered by engineers.

The Association of Iron and Steel Electrical Engineers will hold its eleventh annual convention at Philadelphia, Penn., Sept. 10-14, with headquarters at the Bellevue-Stratford Hotel. The day of Sept. 12 will be devoted entirely to a patriotic program, with addresses by army and navy engineers on vital subjects concerning our industries.

The Society of Industrial Engineers, which was recently organized at Washington, D. C., consists of professional technical engineers, accountants, managing executives in commercial and industrial activities, technical writers, educators and students. It is planned to offer the services of the organization to the Government through Howard E. Coffin, chairman of the Advisory Committee, Council of National Defense, and other such committees as can use the services of industrial engineers. A bureau has been organized under the direction of the president of the society to list all the industrial specialists in the country who may be called upon to serve either as advisers or directors of efficiency work. D. C. Dent, of Chicago, is acting secretary of the organization.

The Engineering Council, which is a department of the United Engineering Society and has recently come into being as a medium of coöperation between the four national engineering societies, held its first meeting in the United Engineering Societies Building on June 27. The council may speak authoritatively for all member societies on all public questions of common interest or concern to engineers, is composed of 24 members, five being appointed by each of the four founded societies (which are the American Society of Civil Engineers, American Institute of Mining Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers) and four members by the United Engineering Society. At the organization meeting the following officers were elected: I. N. Hollis, president; H. W. Buck and George F. Swain, vice presidents; Calvert Townley, secretary; the four officers just named with J. Parke Channing and D. S. Jacobus, executive committee. Ways and means by which the founder societies, through the council, might be of use to the nation were discussed, and the unanimous desire to help the Government now resulted in a resolution instructing the executive committee to coöperate with the Government in procuring the services of engineers. A committee of three, consisting of Messrs. H. W. Buck, A. M. Greene, Jr., and Edmund B. Kirby, was appointed to consider the best means of utilizing the inventive ability of the members.

Miscellaneous News

According to a report compiled by the Government, which has just been placed before the Railroad War Board, 29 per cent. more bituminous coal was hauled by the railroads of the United States in April of this year than in April of last year.

The Columbus Railway, Power and Light Co. effected an increase of 20 to 25 per cent. in commercial electric rates on June 21. The scale is so arranged that the largest consumer must bear the heaviest increase.

The L. B. Stillwell Engineering Corporation has been organized to act as constructing engineers in general engineering construction work. The officers are: Lewis B. Stillwell, president; H. St. Clair Putnam, vice president and general manager; Hugh Hazelton, vice president; W. Everitt Rundle, secretary and treasurer. The principal office of the corporation will be at 100 Broadway, New York City.

Higher Electric Rates in Indiana—The Indiana Electric Light Association has filed a petition with the public-service commission asking increased rates for electric service. A surcharge, not to exceed 30 per cent. of the present rates is desired,, with the understanding that when the cost of operation of an electric plant went up, the rates could be increased and the rates reduced should the cost go down.

Rochester Builds Own Power Plant—Construction work on the first public-owned hydro-electric plant in the state of Minnesota, has been started in Rochester. The dam, which will be constructed of concrete, 60 ft. high, and the reservoir to cover over 1200 acres, will cost about $750,000. Sufficient electric power will be generated to supply Rochester and several of the surrounding villages. Hugh L. Cooper, of New York, builder of the big Keokuk dam across the Mississippi River, is in charge of the project.

Olympia's Engine Room Crew Prove Themselves Heroes—The story of the devotion to duty of the engine-room crew of the United States cruiser "Olympia," which probably saved Admiral Dewey's famous old flagship from going to the bottom off Block Island, when she struck an uncharted rock late one night recently, has just come out. When the ship struck, her port engines were put out of commission, water poured into the engine room and the ship's momentum carried her into deep water, where she was in imminent danger of sinking. When Captain Waldo Evans realized the seriousness of the situation, he telephoned down for more steam in order to bring his ship into shoal water, where he could beach her, and every man of the engine-room crew responded. Working in water up to their waists, they kept the starboard engine running until they succeeded in driving the ship ahead up onto a shoal.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	July 7, 1917	One Year Ago	July 7, 1917	One Year Ago
Buckwheat ..	.....	$2.05—3.20	$6.00—6.75	$3.25—3.50
Rice	.....	2.50—2.65	5.20—5.85	2.70—2.95
Boiler	.....	.....	..... *	.....
Barley	.....	2.20—2.35	4.90—5.00	2.35—2.60

*No prices quoted.

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	July 7, 1917	One Year Ago	July 7, 1917	One Year Ago
Clearfields ...	$3.50—3.75	$1.00—1.55	$7.50—8.00	$4.25—5.00
Cambrias and Somersets..	3.75—5.00	1.30—1.75	8.00—8.50	4.60—5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $4.85—5.25, as compared wtih $2.75—2.85 a year ago; on cars Boston price is $9.00—10.

*All-rail rate to Boston is $2.60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	July 7, 1917	One Year Ago	July 7, 1917	One Year Ago
Buckwheat ..	$4.00—4.15	$2.75	$4.50—5.00	$2.65—2.75
Rice	3.40—4.05	2.25	3.50—4.00	2.20—2.25
Barley	2.90—3.10	1.75	2.75—2.90	1.70—2.00

BITUMINOUS

	South Amboy	Port Reading	Mine Price
Clearfield	$6.75—7.00	$6.75—7.00	$5.00—5.25
South Forks	7.00—7.25	.....	5.25—5.50
Nanty Glo	7.00—7.25	.....	5.25—5.50
Somerset	6.75—7.00	6.75—7.00	5.00—5.25
Quemahoning	7.00—7.25	7.00—7.25	5.25—5.50

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shopped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton r.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	July 7, 1917	One Year Ago	July 7, 1917	One Year Ago
Buckwheat ...	$2.90	$1.65	$3.80	$2.55
Rice	2.40	1.00	3.40	....
Boiler	2.20	.90	3.30	1.80
Barley	1.90	.75	2.15	....

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	July 7, 1917	One Year Ago
Slack	$3.00—3.25	$1.25
Mine-run	3.00—3.25	1.50—1.75
¾-in.	3.00—3.25	1.70—1.85

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current prices per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless	Springfield	Clinton and Sullivan Counties
Steam lump ..	$3.00–3.25	$3.00–3.50	$5.00–5.50	$3.00	$3.00
xLump	3.25–3.50	3.50–3.75	5.00–5.50	3.25	3.50–3.75
Egg	3.25–3.50	3.50–3.75	5.00–5.50	3.25	3.50–3.75
Nut	3.25–3.50	3.50–3.75	.....	3.25	3.50–3.75
No. 1 nut....	3.25–3.50	3.50–3.75	.....	3.25	3.50
No. 2 nut....	3.25–3.50	3.25–3.50	.....	.....	.....
No. 3 nut....	3.00–3.25	3.00–3.25	.....	.....	.....
No. 1 washed.	3.25–3.50	.....	.....	.....	.....
No. 2 washed.	3.25–3.50	.....	.....	.....	.....
Mine-run	3.00	3.00	5.00	2.50–3.00	2.75–3.25
Screenings	2.75–3.25	2.75–3.25	.....	2.25–2.75	2.75–3.00

Hocking lump, $4.25—4.75; splint lump, $4.25—4.75.

St. Louis—Prices per net ton f.o.b. mine a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	July 7, 1917	One Year Ago	July 7, 1917	One Year Ago	July 7, 1917	One Year Ago
6-in. lump..	$3.50	$1.50	$2.25	$1.25	$2.25	$1.00
2-in. lump..	3.25	1.40	2.25	1.15	2.00	.85
Steam egg...	3.40	1.40	2.25	1.10	2.00	.85
Mine-run ...	3.00	1.10	2.25	1.05	2.00	.85
No. 1 nut..	3.50	1.40	2.25	1.25	2.25	.90
2-in. screen..	2.50	.90	2.25	.90	1.75	.85
No. 5 washed	2.50	.70	2.25	.75	1.75	.70

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run		Mine-Run
Pratt	$3.75	Carbon Hill	$3.25—3.50
Big Seam	3.00—3.25	Cahaba	4.00
Black Creek	4.00		

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Ariz., Chloride—The Desert Power Co. has prepared plans for a new transformer station. Estimated cost, $12,000.

B. C., Hollyburn—The British Columbia Electric Railway & Power Co., 425 Carroll St., Vancouver, plans to extend its transmission lines to Hollyburn to furnish electrical service here.

B. C., Nelson—The Utica Mines, Ltd., and the Jackson Basin Mines, Ltd., both of Nelson, have made arrangements to build a hydro-electric plant on Twelve-Mile Creek. The Utica Mine now has a 100-hp. plant. C. F. Caldwell of Kaslo, B. C., is interested.

Cal., Portola—The United States Smelting and Mining Co. plans to build a large power plant.

Del., Wilmington—The Wilmington & Philadelphia Traction Co., 7th and Orange Sts., has filed plans for an addition to its power station on the Brandywine River.

Idaho, Murray—The Yukon Gold Co. has awarded the contract for the construction for an electric transmission line to Pritchard Creek dredging ground, near Murray, to the Washington Water Power Co., of Spokane.

Ill., Dixon—The Illinois Northern Utilities Co., 421 1st St., plans to spend $408,325 to improve and build additions to its plant. J. E. Harlow, Mechanical Engr.

Ind., Decatur—The Ft. Wayne & Decatur Traction Co. has had plans prepared for a 23 x 60-ft. substation.

Iowa, Clermont—C. Miller & Sons, of Clermont, has taken over the plant of the Northeastern Iowa Power Co. and plans to build an addition to same.

Iowa, Mason City—The Peoples' Gas & Electric Co. is making arrangements to extend its electrical service to Kensett and Northwood. T. H. Hughes, Mason City, Ch. Engr.

Kan., Coffeyville—The City Council has purchased a site and plans to build an electric-light plant. E. Cathers, City Engr.

Md., Westport—(Baltimore P. O.)—The Consolidated Gas, Electric Light and Power Co. is having plans prepared by the company's engineers for another substation to be known as Station D. A. Banks, Jr., Pur. Agt.

Mass., Foxboro—The Union Light and Power Co., of Franklin, controlled by C. D. Parker & Co., Inc., Boston, plans to build a high-tension transmission line from Foxboro to North Attleboro. Additional power will be needed to meet the demands in North Attleboro. H. Clark, of Franklin, Mgr. and Contracting Agt.

Mont., Harlem—The Citizens Electric Co., recently incorporated by J. M. Rantschler, H. C. Anderson and others, plans to build an electric-light plant. J. M. Rantschler, Pres.

Neb., Lexington—The Lexington Mill and Elevator Co. has filed an application with the State Railway Comn. for permission to build an 18½-mi. electric transmission line from Lexington to Cozards.

Neb., Omaha—The Nebraska Power Co. has taken over the plant and holdings of the Omaha Electric Light and Power Co. and plans to build extensions to its transmission lines.

N. J., Newark—The Alcohol Products Co., foot of Blanchard St., plans to build a 1-story, boiler and engine house.

N. J., Newark—The Nickelsburgh Bros. Co., manufacturer of leather, plans to build 2 1-story boiler plants at its factory on Meadow St.

Ohio, Niles—The Ohio Steel Products Co. has increased its capital stock from $70,000 to $100,000 and plans to improve and build addition to its plant.

Okla., Gate—City voted in favor of issuing franchise to E. G. Pickett to install electric-light and power plant.

Ore., Medford—The California-Oregon Power Co., 131 Leidesdorff St., San Francisco, plans to extend its electric transmission line from near Glendale through Riddle to Myrtle Creek. H. L. Walthan, Medford, Gen. Supt.

Penn., Chester—The Seaboard Steel Castings Co., recently acquired by the American Locomotive Co., plans to build a new power house in connection with a proposed extension to its foundry.

Penn., Philadelphia—The Philadelphia Electric Co. is receiving bids for a 1-story, 30 x 50-ft. addition to its plant on Schuylkill Ave. and Christian St. W. H. Norris, Ch. Engr.

Penn., Scranton—The Maccar Truck Co., Cliff St., has had plans prepared by Duckworth Bros., Arch., Coal Exchange Bldg., for a 1-story power house at Providence Rd. and Gilligan St.

Utah, Monroe—City plans to rebuild its electric power plant which was destroyed by fire some time ago.

Wash., Everett—The Everett Gas Co. has applied to the County Commissioners for a franchise to construct, maintain and operate an electric transmission line over certain roads in Snohomish County to transmit current for heating, lighting and power. A. S. Harrington, Snohomish, Supt.

Wash., Seattle—J. D. Ross, Supt. of Lighting, will receive bids July 20 for an addition to the hydro-electric power system. City also plans further improvements this year including central substation, $50,000; distribution station, $75,000; pipe line No. 1; $75,000; underground system, $100,000; stores and shop buildings, $100,000.

Wash., Tacoma—City is having plans prepared by Heath & Gove, Arch., National Realty Bldg., for a power plant in the Kapowsin School.

W. Va., Fairmont—Monongahela Valley Traction Co. had plans prepared by Sanderson & Porter, enghs., 52 William St., New York City, for a power plant. E. Moore, Watson Bldg., Fairmont, Gen. Mgr.

Wis., Barron—Common Council will engage an engineer to prepare plans for an electric-light and power plant.

Wis., Sheboygan—The Eastern Wisconsin Electric Co., of Fond du Lac, plans to build an addition to its power plant at Sheboygan. A. G. Carson, Fond du Lac, Supt. and Engr.

Wis., Waupaca—The Wisconsin Veteran's Home made application to the State Legislature for an appropriation of $60,000 to build a power plant. Address the Superintendent.